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Mind and Work

Charles S. Myers

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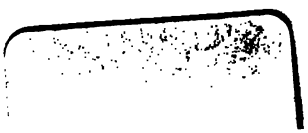

MIND AND WORK

MIND AND WORK

THE PSYCHOLOGICAL FACTORS IN INDUSTRY AND COMMERCE

BY

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INTRODUCTION

THIS book may be regarded as an expansion of part of my *Present-day Applications of Psychology*, the fourth edition of which is now out of print. It contains the substance of various lectures and addresses, which I have given during the past two years, on the relation of psychology to the well-being and efficiency of industrial and commercial workers.

Of the four main determinants of industrial and commercial efficiency—the mechanical, the physiological, the psychological, and the social and economic—the psychological is by far the most important and fundamental. Intelligence in foreseeing demands and in improving industrial conditions, and a sympathetic understanding of the standpoint of others, are much more "productive" than mere capital or mechanical labour. The physiological factors involved in

purely muscular fatigue are now fast becoming negligible, compared with the effects of mental and nervous fatigue, monotony, want of interest, suspicion, hostility, etc. The psychological factor must therefore be the main consideration of industry and commerce in the future; and in the following pages I shall endeavour to show its importance in (i) movement study, (ii) fatigue study, (iii) selection study, (iv) incentives study, and in (v) industrial unrest. In movement study it will prove necessary also to take into consideration mechanical and physiological factors; in fatigue study, certain physiological factors; in describing the methods of selecting workers according to their special aptitudes, the standpoint will be principally psychological; while in considering the incentives towards increased efficiency (in the chapters headed "Restriction of Output" and "Systems of Payment") and the causes of industrial unrest, social and economic considerations must necessarily be introduced.

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MIND AND WORK

I

CHAPTER I

MOVEMENT STUDY

Its three aspects—Examples of motion study—Importance of initial training—Needless stooping, walking, and standing — Principles of motion study — Monotony in motion study—Use of the cinematograph —The chronocyclegraph.

CHAPTER I

MOVEMENT STUDY

MOVEMENT study may be broadly regarded from three aspects. The first of these relates to the planning of the factory or business, including the arrangement of tools and materials; the second to the division of work among skilled and unskilled employees; and the third to the learning of the best movements in work. The last is generally known as "motion study."

The planning of the factory or business involves, among other things, the proper organization of administrative departments for specification, costing, order of work, instruction, material, and stores, and the proper location of the different industrial or commercial operations. On this particular aspect it is unnecessary to dwell, as its technical nature lies beyond the province of the psychologist. Two statements, however, may be repeated which have been

made elsewhere—(i) that only two and one half per cent. of the industrial firms in England, in contrast to ten per cent. in the United States and ninety-two per cent. in Germany, have established efficient systems of costing; (ii) that in a certain works, whilst wages are calculated in tenths of a penny, it often costs *2s. 6d.* to get a split pin out of the stores!

A few striking instances will be now quoted where industrial efficiency has been improved by a better arrangement of tools and materials. The New England Butt Company, for example, was engaged in manufacturing machines for braiding called "braiders," and an expert was called in to apply movement study to the factory. He found the tools lying anywhere, the base of each braider placed on an ordinary low bench, with the various parts kept on the floor or in boxes.

No special method was being taught. The assemblers[1] worked by tradition, or according to individual fancy. The conditions must have resembled those obtaining in a factory in this country, where it was recently calculated that

[1] "To assemble" means to fit the parts together.

seventy-five per cent. of the time was spent in handling the tools, fifteen per cent. in handling the machine, and only ten per cent. on the actual job!

The expert proceeded systematically to study the best positions for the tools and parts before assembly. The latter he arranged in definite order on a vertical trellis frame called a "packet" (Fig. 1), which he provided with arms and hooks so as to allow the parts to be placed in the most convenient position for the assembler's grasp. This packet was loaded by an apprentice, who was meanwhile being trained in the principles of assembly. Henceforth, the tools were placed in pre-arranged order on the table, and the table was so designed that it could also be used when turned over on its side, thus providing a table of two heights, one for the ordinary, the other for the taller or "double-deck" braiders. The result of these improvements was that, without increased fatigue (and with increased earning), a man could assemble sixty-six braiders per day, in place of a previous output of eighteen per day; that is to say, a 266 per cent. increase in rate of output was obtained.

Another instance of the effects of movement study occurred in the Derwent Foundry Company, Derby, which was engaged during the war in making Mills's hand grenades and what are called "fuse-hole plugs." These fuse-hole plugs fitted into the top of shells in place of the fuses until the shells were wanted for actual use. The managing director of the foundry came to the conclusion that he could enormously improve the output without causing a greater amount of fatigue among the workers. So, broadly following F. W. Taylor's method, he set to work, with two or three men whom he could trust, including his works manager, to analyse each small job, in his and their cases, into its essential component movements, and to time these movements with a stop-watch in order to see how he could improve the movements. Having done this to his satisfaction, and having drawn up a list of the "standard times" of each separate unit movement and the "standard time" in which the whole job should be performed, he devised instruction cards on which these estimates were entered. He deducted ten per cent. from what he had evolved as

FIG. 1.—"Packet" designed to facilitate assembly movements (Gilbreth).

standard times, so as to allow the worker forty-five minutes during the day to attend to his personal needs, and also to allow for accidental waste of time; and then, after making various improvements in the arrangement of materials, in the efficiency of the machining, and in the co-ordination of the moulders' and labourers' work, he turned to his workers and asked them to allow themselves to be trained. He said: "We are out for shorter hours, higher wages, and more output; will you help us?" They said they would. His object was to train them individually so that needless movements could be eliminated, and so that they might adopt the best and most expeditious methods. As soon as each worker began to be trained, his hours were reduced from fifty-four to forty-eight a week, and he received twenty-five per cent. higher wages than the ordinary day wage of the district as an inducement for him to continue his training. When the men began to produce at the standard rate, they were put on to a special system of payment which he had devised, in which piece-rate and bonus systems were combined. In the early days they did not fully appreciate the

working and the advantages of this system, and some of the older men were disinclined to give up the older methods; they were in a groove from which it was difficult to escape. To any such grumblers the managing director said: "If you do not like it, you can come to-morrow morning as before at six instead of eight o'clock and go back to your old wages." There is good reason to believe that some of them would have done so if it had not been for the tact of the managing director and his works manager.

The result was as follows. At the outset the Ministry of Munitions had estimated that the foundry would turn out three thousand articles a week. In the end they turned out twenty thousand. Part of this difference, of course, may have been due to an underestimate on the part of the Ministry of Munitions; but in order to obtain a better basis for comparison, the managing director later visited a foundry which had actually more machinery than his firm had, and he observed that while his firm was turning out twenty thousand a week, the other foundry had difficulty in turning out five thousand such units. There is hence no doubt as to the enorm-

ous increase of output in his own foundry due to his methods. It is an extremely difficult matter, of course, to determine how much of this improved efficiency was due to movement study, how much to shorter hours or higher wages acting as an incentive, how much to better food arising from higher wages—for there had been a striking improvement in the general appearance of the workers after the increase of pay—and how much to increased efficiency of the machinery and better organization of the factory. It is probable that in the actual moulding and casting, about ninety per cent. of the increased output was due to improvement in the human factor, and that more than twenty per cent. of this was due to training in the best movements. In the machining, of course, the improvement was largely due to improved machinery.

I will present a few figures which may make the results still clearer. In the ten-hour day, worked under the old system, this foundry produced an average output of forty-eight of a given item. After the introduction of movement study the standard output, based on stand-

ard times, rose to 147 per day of eight and three quarter hours, which represents nearly a 284 per cent. increase in hourly rate of output. But this standard output was regularly surpassed by all the trained adult workmen! The increase in actual earnings in the case of one worker (chosen at random) was found to be, roughly, two hundred per cent., while the reduction in his working hours was about eleven per cent. When fourteen of the men and women, chosen quite haphazard, were interviewed by a visitor in the moulding and machine shops, they expressed themselves as perfectly contented with the new system and evinced no desire to return to the old conditions. There was no general evidence of increased fatigue; indeed many of them said the fatigue was less, and several of them preferred the new system because it involved less idling, or because under the old system they were called continually and irregularly from one job to another, whereas now they had a more methodical kind of work. Throughout, the trade-union officials placed no serious obstacle in the way of the scheme, although neither they nor the employers' federation

regarded it with favour. The difficulties arising in relation to this aspect of the subject will be considered later (Chapter VI).

As another instance of the working of such methods elsewhere, an operation in moulding may be quoted which had previously taken fifty-three minutes, but which, an expert reported, could, with proper training in improved methods, be done in forty-four minutes. After some practice, the men took twenty minutes for it! That is, there was an increase of 165 per cent. in the rate of output; and one of the men actually averaged sixteen minutes during a whole day's work. The labour cost was reduced by fifty-four per cent., while the earnings were increased by sixty per cent.

An operation in yet another factory taking 2.17 minutes was reduced by motion study and training to half a minute. The scheduled time in which the work should be performed was, therefore, put—to make full allowances—at thirty per cent. over this half-minute. In six months most of the girls had surpassed it by thirty or forty per cent., so that they had reached the half-minute, which was equivalent

to a 334 per cent. increase in rate of output; the wages of the workers at the same time rising by fifty or sixty per cent.

In the Ferracute Machine Company in New Jersey, with practically unchanged equipment and a constant number of employees, motion study reduced the time of performing 275 jobs by thirty-eight per cent., and it reduced the total cost, including overhead expenses, by forty-seven per cent.; the average day rate paid to the workers being increased by eleven per cent., with a bonus increase of from twenty to sixty per cent.

In the correspondence department of a printing office, where girls had to fold letters with enclosures, motion study increased the output by about three hundred per cent.

In cotton folding the number of separate movements was reduced from twenty or thirty to ten or twelve, with the result that instead of 125-dozen pieces, four-hundred dozen pieces were folded in the same time, without any increase of fatigue.

In a sweet factory of this country the output in a certain department was almost doubled by

motion study and subsequent training. The percentage of working time wasted in such unproductive labour as fetching and replacing trays was reduced to nearly one third of its previous amount.

The following table (page 16) gives some further data resulting entirely, or almost entirely, from motion study.

Everybody who has had to do with motion study lays stress, as may be imagined, on the importance of the initial training of new workers. If one can get hold of an employee from the start, instead of allowing him to become fossilised in antiquated methods or to pick up his own methods, one saves enormously.

Clearly one of the main principles of motion study is to eliminate needless movements, especially such as unnecessary stooping or walking. Bricklaying is a striking example of wasted effort in movement. It was in connection with bricklaying that modern motion study was first applied, trebling the number of bricks laid per man per hour, without increase of effort. When one considers that for centuries bricklayers have continued stooping down and

Nature of Work	Percentage increase in rate of output	Percentage reduction in cost	Percentage increase in earnings, etc.
Midvale Steel Co.	not given	41	40
Bleaching	200	40 (labour cost)	40
Yale & Towne Manufacturing Co.	not given	32 (labour cost) 31 (overhead charges)	not given
Tabor Manufacturing Works (moulding machines, etc.)	200	not given	25–30
Link Belt Works (elevating and conveying machines).	100	50 (labour cost) 20 (total cost)	25–30
Joseph & Feiss Co. (cloth making)	70	10 (by reduced cost of supervision)	70 (Hours reduced from 54 to 45 and less)
Putting paper covers on small boxes	100	not given	not given
Drilling holes in metal	300	"	"
Bricklaying	192	"	Great increase
Bleaching shirtings about	80	about 60 in wage cost	About 140
Putting up cloth about	150		
Packing cloth about	170		
Pillow case making about	230	about 50 in wage cost	
Cotton plant	100	not given	not given
Drill Press Factory	100	"	"
Cotton cloth folding	220	"	"
Unloading pig iron	500	66	69
Other handling of pig iron	300	60	60
Shovelling	270	54	"
Riveting	69	not given	not given
Sulphate Pulp Mills	100	"	"
Tobacco Pouch Factory	100	"	"

picking up bricks and mortar, when one thinks of the amount of needless work involved in thus lowering and raising through some two feet about one-and-a-half hundredweight of trunk and head so many times a day—whereas one could easily save fatigue and increase output by arranging the bricks and mortar in more convenient positions and in convenient quantity and quality for the work—one realises how deeply rooted and how difficult to change are archaic, inefficient methods of work. There must be few factories at the present day where it would be impossible to reduce fatigue by abolishing needless stooping and by devising proper seating accommodation with sliding seats, back rests, foot rests, etc. This has already been done in various workshops, especially in America, and has effected a considerable saving of fatigue and increase of output.

Another principle of motion study is to try to combine separate movements into a single movement, one uninterrupted (circular) movement being generally less fatiguing than two separate (angular) movements. Yet another principle is to combine, as far as possible,

similar movements of the two hands at the same time. It requires much more effort to raise first one hand and then the other, than to raise them both together; a good deal of saving has been effected by this method of simultaneous, symmetrical movements of the two hands. Another principle of movement study—this list does not pretend to be exhaustive—is based on attention to rhythm of movement. Obviously it is much less fatiguing to perform an act rhythmically than by an irregular series of jerky movements; of course, every person has his own best rate of repetition of movement, a rhythm peculiar to himself.

Having alluded briefly to the advantages of the system of trained movements, let us now turn to one of its principal disadvantages, leaving a discussion of the others until the consideration of industrial unrest is considered in Chapter VI. The great disadvantage which has been urged against movement study will probably have occurred already to the reader. It is the monotony of always employing one and the same method. But of this one cannot well judge as an outsider, without inquiring from the

workers themselves as to whether they find the effects of movement training monotonous. To the uninitiated, angling, when unrequited, appears so boring and senseless a sport as hardly to be fit for a sane person. So, too, an apparently monotonous occupation may to some prove full of interest. At the foundry already mentioned, practically no evidence could be obtained of workers objecting to the monotony of the processes. It is true that there were two persons, of the fourteen specially questioned, who spoke about their work being monotonous; but when one came to cross-question them, they appeared to be people who would also have found the previous conditions of work monotonous. There are, of course, wide differences in individuals, but there can be no doubt that a large number of factory workers, like the majority of domestic servants, prefer the even tenor of their way. In every social stratum there are many folk who do not care to use their brains much; they just want to carry on, week after week, doing the same things, day-dreaming perhaps during their day's work. That is to say, a more or less monotonous occupation is

actually welcomed by some people, just as there are others who cannot exist without variety. Whether or not such mechanical occupation is good and should be encouraged, and how far preference for it is acquired by stress of circumstances (*cf.* p. 160), need consideration. But the fact remains that all occupations involve a certain amount of drudgery, and where the drudgery is necessarily great, the possibility of compensation by shorter hours or higher wages and the selection of those who prefer a humdrum life, also demand consideration.

We must remember that the worker, whether trained in motion study or not, will ultimately fall into *some habitual method* of procedure. The training of a new worker merely shows him one of the most economical methods and prevents in him the formation of bad habits. It need not turn him into a machine any more than if he were left to his own devices. All must depend on how the fruits of motion study are applied, whether in a psychological or in a mechanical spirit. Shorthand reduces fatigue and increases efficiency, but there are various methods of shorthand just as there are various

first-class styles of golfing or violin-playing. It is psychologically most improbable that any one good method or style can ever be the best for all persons, and it remains for psychological research to determine the relation between individual physical and mental differences and the different methods needed to satisfy these differences. While the employee should be trained from the start in what has been proved to be one of the best methods, he should be at full liberty to substitute another, if he prefers it and can show that it is as effective. To aim at pressing all workers into the same mould is not only to destroy individuality and to encourage needless monotony, but also to run counter to known psychological principles. It is the outcome of so-called "scientific" management, mechanically formulated by the engineer, in which the mental factors of personality, sentiment, and sympathy are sacrificed to purely physical considerations.

Moreover, when a worker has been trained in a good method, he will, if he is worth anything, and if sufficient incentive is held out to him, take an interest in discovering a still better

method; in a properly organized factory he will be rewarded—and *adequately* rewarded—for his discovery.

In any case, monotony may be guarded against by a proper system of promotion. An intelligent factory worker will wish to be trained in part of his time for a higher post, and in return will be prepared to train someone else to take his place. Another way in which better facilities for change can be created is for the worker to be allowed to gain proficiency not merely in one little job but also in other jobs, so that he may vary his work and be transferred, in cases of illness or of seasonal fluctuations in demand, from one job to another. Again, if one man be teaching another, and it is found that he is a good instructor and interested in instruction, he can be made to undertake that work *par excellence*.

But more important than any of these various methods of warding off monotony is the encouragement of the worker to take an intelligent interest in the factory as a whole; and so far very little has been done in this respect. The worker must be educated in the general

work and aims of the factory. He can no longer be considered a mere piece of machinery. Especially where the worker is allowed some voice or representation in matters on which he is competent to express an opinion, motion study cannot fail to bring the worker into closer contact with management. Moreover, it alters the whole system of apprenticeship and the tradition of craft knowledge. This so-called system cannot but change after the exposure of its futility and the lessons we have learnt during the war. It will be discussed in Chapter VI.

With regard to the details of scientific motion study, much research must be done in a special laboratory. Motion study has as yet been scarcely touched by the psychologist. It has hitherto been mainly the purview of the industrial "efficiency expert." But there is obviously a vast field of promising scientific research here. The present methods are largely empirical and guesswork. The efficiency expert pays a visit to a factory where he sees a worker making a series of seemingly needless movements. He believes that time will be saved by training the worker to another, an apparently

"shorthand," method. He tries it, and, we will suppose, he finds that time is saved by its adoption. He assumes that, because a speedier method has been devised, there is no increase, or there is a decrease, of fatigue. He assumes that because this method is found to suit one worker, it is therefore the one and best method, necessarily to be adopted for all purposes by all workers. Or he arrives at the "best" method by combining the quickest movements observed in one worker in one element of the job with the quickest movements observed in another worker in another element of the job, and so on—a psychologically unwarrantable and vicious procedure.

Clearly there are numerous problems for systematic experiment here, by which the applied science of Industrial Psychology will be advanced to surer ground. We need, moreover, to ascertain how far movements necessarily differ when the same job is performed slowly and when it is performed at the proper speed, and whether it follows that in training movements more stress should be laid on poor quality of work at the standard speed than on better

quality at a slower speed. Similar scientific work is needed to yield reliable information in regard to other matters which are intimately connected with motion study, *e.g.*, the optimal load and posture, the optimal rate and duration of lift, etc., in persons of different muscular power, age, and sex.

It is obvious that the movements of the workers can only be scientifically studied and trained with their full consent and co-operation. In this respect there was an egregious failure in the early stages of so-called "scientific" management in America. For example, F. W. Taylor, the great founder and leader of the movement would sometimes go into factories with a sham note-book specially devised to contain a stop-watch inside it, so that the times of the workers' movements could be studied without their being aware of the fact. Nothing could be more disastrous to the whole subject than this. Taylor was, of course, a most capable and brilliant worker in the administrative, technical, and mechanical details of industrial management; but such tactlessness as this, especially when perpetuated by less competent disciples,

helped to put back the clock of progress of motion study a great many years. If it were thus introduced into another country, the whole system would stink in the nostrils of trade unions and the workmen generally. In actual practice, indeed, the stop-watch should never be introduced until the full confidence of the workers has been obtained. Otherwise they suspect that its object is to speed them up unduly, instead of to detect and to eliminate useless, wasted effort. Much motion study can be done without a stop-watch. When the latter is first used, it should be applied in private —to one or two selected employees—or in the laboratory.

In certain favourable conditions, an instrument more refined than the stop-watch may be desirable. With the development of the cinematograph, that instrument has been applied so that an actual picture is taken of the movements which are being investigated. It is often difficult, when one has merely a record of times, to know precisely what are the movements to which the times refer. At first, a clock was photographed at the same time, so

that the position of the clock hands at any one phase of movement in any one photograph afforded data for time study as well as for movement study. But there are certain objections to the cinematograph, and for these reasons the "chronocyclegraph" was devised. In the first place, some obtruding part of the body is often apt to conceal in the cinematophotograph an important phase of the movement. In the second place, when a photograph is taken, it is limited to the angle from which the camera views the subject, whereas in the chronocyclegraph this is avoided. Lastly, the cinematograph is an awkward means of providing instruction, and also an awkward instrument for analysing the different movements. In the chronocyclegraph a wire model of the actual movements (Figs. 4–6), is ultimately made. This is a very much simpler method, both for analysing the movements and for instructing the person, because he sees the whole of the movement before him; he can see any part of it at any moment he chooses, instead of having to unravel the film; and he can look at the wire model of the movements from different direc-

tions, which is impossible in a film taken by means of a cinematograph camera.

Fig. 2 shows the beginning of Gilbreth's chronocyclegraphic method, illustrating the movements of the American amateur ex-champion golfer, Francis Ouimet. The method may be described roughly as one of photographing a rapidly moving lamp. The end of Ouimet's club bears a small glow lamp, which thus shows the movement of his drive. It is a fine

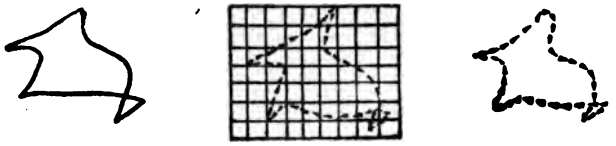

FIG. 3.

graceful movement, characteristic of the practised artist.

Fig. 3 shows the gradual development of the chronocyclegraph. In A, as in Fig. 2, there is a continuous (here black) line of light. Gilbreth's next step was to introduce into the electric circuit a tuning-fork vibrating fifty or one hundred times a second, so that instead of a

FIG. 2.—Record of a champion golfer's swing (Gilbreth).

single line of light he obtained a number of interruptions of light owing to the current being interrupted, let us say, one hundred times per second. Then he pointed these dots of light (as in B), which he effected by breaking the current in such a way that the light glowed less as it disappeared than when it first began. The object of this was to have an indication of the direction of the movement in the photograph, the forwardly pointed ends showing at once that the movement in the photograph was, say, from left to right, not *vice versa*. Lastly, if one knows the distance between the squares in a wire screen (see C) photographed on the film beforehand, one has all the information wanted for motion study. Having obtained such a photograph, which itself went far beyond the long continuous line shown in Fig. 3 A (and in Fig. 2, the photograph of the golfer), Gilbreth now went further. Instead of a single photograph of the movements, he took a double one so as to obtain the movements in relief; and having secured that stereoscopic effect, he then proceeded to construct a wire model of the movements.

Fig. 4 shows the construction of the wire model. The expert is shown looking down a stereoscope, building up a wire model from the chronocyclegram. He has a screen in front of him, which tells him exactly the dimensions. Finally, the wire model is painted, as in Fig. 5.

Fig. 4 is a wire model of the movements of the left hand in working a drill press. Fig. 5 is a wire model obtained from the movements of a girl's left hand during the operation of folding handkerchiefs. The model is painted in white, and it is shaded through grey into black in order to show the direction of the movements.

Fig. 6 is of interest, as showing the effect of practice on the movements illustrated in Fig. 4. I am informed that the worker had previously been practised, but had not got back into his old form. On the second (second from the left) attempt, he improved; on the third he was better still; and, finally, he was at his best, and this stage corresponds almost exactly to the original (*cf.* Fig. 4) which is considered a perfect model.

The writer is indebted to Major Gilbreth for

FIG. 4.—Construction, from chronocyclegraph, of wire model of left-hand movements in working a drill press (Gilbreth).

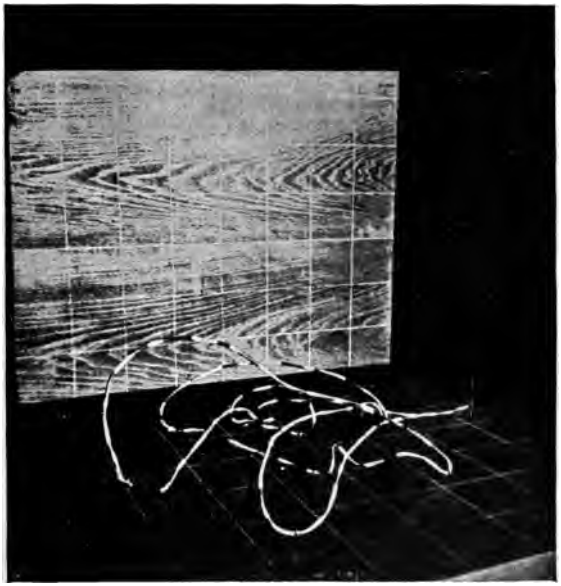

FIG. 5.—Model of left-hand movements in folding handkerchiefs (Gilbreth).

FIG. 6.—Model of drill press movements showing practice effects (Gilbreth).

his kind permission to publish his photographs (Figs. 1, 2, 4, 5, and 6).

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CHAPTER II

FATIGUE STUDY

The four aspects of fatigue—The ergograph—Fatigue and increased output—Mental fatigue—Boredom and weariness—Methods of estimating fatigue: factory methods; apparatus; tests of nervous and mental efficiency—Factors affecting the work curve—Holiday and Monday effects—Variations in work curve—Physiological fluctuations—The load lifted—Needless standing and stooping—Effects of illumination, noise, ventilation, temperature, humidity, etc.—Importance of rest pauses—Effects of reducing hours of work.

CHAPTER II

FATIGUE STUDY

FATIGUE has long been a subject of research both by physiologists and by psychologists. The physiologist has generally investigated it under the simplest experimental conditions. For example, he has removed a single muscle with its nerve from the body, and has studied the phenomena of fatigue produced in it by electrical stimulation, observing the effects of varying the strength and frequency of stimulation, the surrounding temperature, the weight lifted by the muscle, etc. He has also investigated the effects of muscular exercise on the general metabolism of the organism. The psychologist, on the other hand, has conducted exclusively "human" experiments, treating the organism as a whole in place of using "muscle nerve" preparations. He has approached the problem from the standpoint of mental, as well

as from that of muscular, fatigue. He has devised "tests" of mental fatigue, constructing "work curves" of mental output, and analysing the psychological factors which determine the forms of those curves, such as spurt and practice. He has studied the effects of drugs, *e.g.*, of tea, coffee, strychnine, and alcohol, on mental and muscular fatigue. He has examined the effects of rest pauses of different length, introduced after varying periods of work, on mental efficiency. He has shown the unreliability of certain interpolated tests as evidence of muscular or mental fatigue; he has shown the importance of a rigorous, precise training in the methods of experimental psychology in order to avoid the pitfalls incidental to human experiment; and he has so prepared the way for a systematic investigation of the problems of industrial fatigue that future success must depend on intimate psychological and physiological co-operation.

There are several physiological views conceivable of the nature of fatigue. One is that living matter becomes fatigued when it has used up all the stuff available for its activity, and that it then needs rest for the manufacture of

fresh stuff for its subsequent use. This conception applied to muscular fatigue, as being due to the exhaustion of consumable fuel, is probably in fact never seriously realised. There are at least three other kinds of "fatigue" which step in and prevent our muscles being reduced to such an *impasse*. The nerve fibres which carry impulses from the central nervous system to voluntary muscles terminate in the latter in delicate "end plates"; these end plates are themselves "fatigued" before the exhaustion of the muscular tissue can occur.

Another physiological conception of fatigue is that it arises from the working parts of the organism becoming choked with the products of their own decomposition. For example, muscular tissue during contraction breaks down to yield carbonic acid, lactic acid, and other substances. If these are allowed to accumulate in the muscles faster than they can be removed therefrom by the lymphatics and the blood stream, they impede more and more the activity of these muscles. But any serious effects arising from this second conceivable source of muscular fatigue are likewise usually safe-

guarded by the action of the nervous system. For when a muscle is voluntarily contracted, it sends impulses up certain nerve fibres to a nerve centre in the spinal cord, the effect of which is increasingly to inhibit (*i. e.*, to suppress) the nervous impulses which would normally travel down other nerve fibres and produce further contractions in that muscle. This is what occurs when a single muscle is exercised to lift and lower a given weight by a series of willed rhythmical contractions. The contractions become less and less, until at length the inhibition set up by them is so great that no amount of voluntary effort can produce further movement in the muscle.

The ergograph enables us to study the onset and course of "fatigue" in a single muscle of the living body. It yields a record of the extent of successive contractions. In Kräpelin's form of the apparatus (Fig. 7), the hand is immovably fixed by the clamps A and B, palm downwards, with the middle finger alone left free. This finger is connected to the wire N by means of a metal box E, into which the finger fits, and by means of the steel ribbon H attached to the box

and to the spirally grooved cylinder J. The wire passes round the cylinder and then over a pulley (fixed several feet above the board X), and a weight W is attached to the other end of

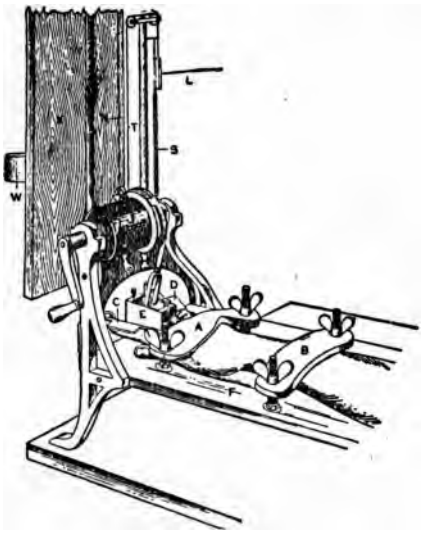

FIG. 7.

the wire. As the finger is voluntarily bent and extended to the rhythm of a metronome, the cylinder winds the wire round it and the weight is raised. At the same time, a diagram of the extent of each flexion of the finger is recorded by the lever L, which is attached by the cord

T to the cylinder J, and is brought to bear on a travelling smoked surface. In this way an ergogram (Fig. 8) is obtained, showing the extent and the number of the contractions until the stage of absolute impotence is reached.

This instrument is not to be regarded as an indication of muscular fatigue. It is rather a record of the capacity to work under given conditions. For, supposing that the weight to which the finger has become completely "fatigued" is five kgs., a new ergogram can be at once obtained by reducing the weight to four kgs. Or if an electric current be applied to the nerve supplying the "fatigued" muscle, the latter will again contract.

The "fatigue" occurring in ergographic work is, as we have seen, not truly muscular fatigue. It is the result of nervous inhibition, due not so much to merely *excessive* as to excessive *monotonous* work, and relievable by changing the conditions of work. The "fatigue" arises from nervous impulses ascending to the spinal cord from the muscle, and there preventing (by "inhibiting") further muscular activity. Nor does fatigue—whether occasioned by the action

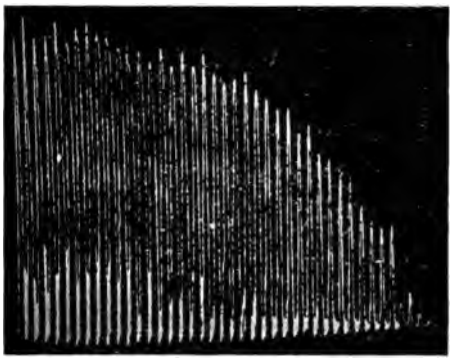

FIG. 8.—Ergogram, showing the onset and progress of "muscular fatigue."

of a single muscle as in ergographic experiments, or by the action of a great number of simultaneously or alternately contracting muscles, as in everyday life, or by mental activity—necessarily give rise to general inefficiency at the moment. When a person is actually fatigued, or feels fatigue, he may temporarily do far better muscular or mental work than when he is not. For at a certain stage, fatigue (like alcohol) may produce general excitement and instability owing to the action of its poisons on the higher regions of the nervous system which normally control the lower. Hence may arise a temporary extravagance in the expenditure of energy, the organism living recklessly, as it were, on its capital (*cf.* pp. 138–140). Conversely, the fact that a person feels fresh does not ensure that he will be able to do the best work. At a certain stage (again like alcohol), fatigue may produce a feeling of ability to work well, but the work may fall very short in quality, if not in quantity, of the work done under normal conditions. Therefore, fatigue and the feelings of fatigue or freshness afford no indication of the work that can be immediately performed.

We have shown that through the control of the spinal cord local inhibitory processes are set up, which prevent the evil effects of excessive monotonous *muscular* excitation. In monotonous *mental* work a somewhat similar local protective function can be observed. When we are engaged on any one piece of mental work, other mental processes are at first inhibited which are incompatible with it; but the onset of local cerebral fatigue is safeguarded by the gradual failure of these processes of inhibition. The inhibited mental processes sooner or later refuse to be suppressed. Other mental activities accordingly intrude, and by *their* inhibitory and disconcerting action make the continuance of the monotonous mental work impossible.

The constant effort of the self to overcome these intruding inhibitions of local muscular or mental monotony is usually accompanied by feelings of "boredom" as interest—*i. e.*, the pleasurable incentive in the work—wanes, and later by feelings of "weariness" as that effort is invoked with great difficulty. The weariness of any monotonous occupation is thus a warning

against the continuance of that occupation. It betokens an impairment in the efficiency of those processes which enable us without undue conscious effort to concentrate on a single activity.

In practice the need for conscious concentration is greatly lessened by habit. But even when an often-repeated action has become so automatic as to be performed better without conscious attention, nevertheless, a special "attitude" has always unconsciously to be preserved, and fatigue sooner or later arises in the inhibitory processes required to maintain that attitude. Hence even in such monotonous routine industrial occupations as labelling, adding, or letter sorting, feelings of boredom and weariness arise; and finally indeed such warning "neurasthenic" experience as, "I could shriek. I feel as if I want to hit somebody."

Boredom therefore occurs during work in the absence of interest. It may arise quite early and apart from fatigue, when interest was initially weak, as when we have yielded to join in a game of cards from which we gain no amusement. Or it may arise late when the interest,

though intense at the outset, finally wanes through the fatiguing intrusion of competing interests. Moreover, boredom may be independent not only of cerebral fatigue, but also of muscular fatigue. Not only may we be bored soon after starting a game in which we take no interest, but we may become physically fatigued in a game which has aroused no feelings of boredom whatever.

Boredom can be alleviated by increased interest, and any ill effects of it may be prevented by a change of occupation. But where serious effort of the will has been made to keep the attention concentrated—when boredom has given way to weariness—change of interest or of occupation is no remedy. Higher control is actually fatigued and cannot be immediately employed for concentration in another direction; for the synapses (*i.e.*, the points of contact between adjacent nerve cells and their processes) concerned in self effort are most sensitive to fatigue, and this fatigue enters into and affects all other subsequent self effort.

The probability is that when fatigue acts on the synapses in the brain we have to do with

a central nervous fatigue not in the sense of an exhaustion, but as the result of a chemical poisoning. This leads at first to a more or less useful change of action—*e. g.*, to a central blocking, or inhibition of central nervous impulses—but later to a serious disorder of central nervous function, involving inco-ordination and loss of higher control (*cf.* p. 139). The nervous system is to be regarded as a system of relays of nerve arcs, the higher controlling the lower; the higher being the more recently acquired and the more susceptible to the effects of drugs and the products of metabolism.

We conclude, then, that monotonous application for long hours at relatively light work induces an incapacity as serious as employment for shorter hours at more strenuous work. Indeed, in certain circumstances the incapacity may be more serious—*e. g.*, when the lighter work is mainly of a mental character, watching and controlling a small piece of machinery that does everlastingly the same job, and when the heavier work is mainly of a mechanical character, say, lifting huge weights of iron. In the latter case the main source of fatigue arises, as we have

seen, from the accumulation of waste products in the muscles, and especially from the spinal inhibitory processes arising from unchanging muscular exercise. Such nervous inhibition, however, has its seat in lower and far less important nerve centres than in the former case, and probably differs from it in nature. The volitional efforts made to overcome such muscular incapacity are much less baneful than those made to overcome the boredom and weariness arising from mental work. Hence the pathological expression of continued fatigue—*i. e.*, overstrain—is far less prevalent in muscular than in mental exertion.

The foregoing account indicates the difficulty of measuring fatigue. We can hardly expect to measure anything unless we have a certain means of recognising it. We might at first feel disposed to define fatigue by its effects—as a diminished capacity for work induced by previous activity. But we should thereby ignore the fact (*cf.* p. 41) that fatigue does not necessarily produce an immediately diminished output. However, despite the complex factors (local and general, higher and lower, metabolic

and inhibitory, boredom and weariness) that affect output and are inseparable from fatigue, we seem forced (but only with approximate accuracy) to assume that "fatigue" is generally proportional to the reduction in output.

The best means, on this assumption, of determining fatigue (whether the fatigue be of experimental or of industrial production), is hence afforded by the study of the quantity and quality of output during equal successive intervals of the day. A less reliable method industrially available consists in observing the machine power hourly used. Yet another is afforded by a study of the amount of spoiled work, the assumption being that as fatigue increases there must occur more and more spoiled work. Again, the number of accidents arising through inefficiency affords some index of the degree of fatigue of the workers. In the London Docks, for instance, more than twenty-five per cent. of the accidents are said to occur between 11 A.M. and noon, and between 3 P.M. and 4 P.M. That is to say, towards the end of the morning they are more frequent than at the beginning, and towards the close of the after-

noon they again become far more frequent, which agrees with the course which fatigue may be expected to follow. But in the factory we must take into account the reduced number of the machines at work, and also the frequent presence of a "spurt" towards the end of the day, which may mask any underlying fatigue. These and other complicating factors, *e.g.*, the increase in the number of accidents with the increase of output (in the absence of fatigue) and with the inexperience of the worker, inevitably enter into the problem. Thus, if fatigue is present, the number of accidents will not fall in proportion to the diminution of output towards the end of the day but will rise, and it will rise earlier in the day far more than would be expected from any rise in output. Lastly, the amount of lost time and sickness may serve as an indicator of fatigue, or at all events of inefficiency.

A test of industrial fatigue has been devised in the form of a "dynamometer," which is in effect a spring balance; the average strength of pull, obtained from a number of muscles in different parts of the body, being used as the

basis for the estimation of fatigue. This spring balance is pulled against by the forearm, wrist, leg, etc., and the subject uses all his strength to resist the increasing traction of the spring applied by the examiner. There is, however, always a danger of inaccurate results when such a test as this is "interpolated" at various hours in the course of a man's daily work. There is always (*a*) the possibility of conscious limitation of efficiency at the test by the subject, (*b*) the difficulty of applying the test in exactly the same way on each occasion, (*c*) the effect of practice, and (*d*) the certainty of a change of interest (*e.g.*, keenness, boredom, or annoyance) in passing from the day's work to the test; the results of such change of interest being favourable or unfavourable to the test.

If a brief test *must* be interpolated, it should be one that is not under the subject's control. Tests which have been suggested with this object refer to changes in the blood circulation (*e.g.*, in blood pressure, pulse, return of normal colour to the skin after momentary pressure thereon) and in the respiratory gaseous exchange. But these, uncertain as they are at

present, can hardly be expected to measure accurately the most important kind of "fatigue," namely that due merely to changes in the central nervous system. Possibly the reflex actions or the electrical resistance of the skin may prove valuable in this direction. But in attempting to establish tests of fatigue which are beyond the subject's voluntary control, we still run the risk of the disturbing effects of involuntary, *e.g.*, emotional, influences upon them. The subject may be alarmed at the apparatus, or irritated or pleased at the interruption in his work. Tests of a purely physiological nature must be thereby affected.

Various "mental" tests have also been devised, but the dangers of change in interest and emotional state, which have been just mentioned (apart from the effects of practice and other factors which will be mentioned in the next paragraphs), are still more important here—in such test, for instance, as depend on speed of reaction to prescribed signals, memory, arithmetical calculations, keenness of vision, and hearing. Therefore, if mental tests are adopted, it is better that they should constitute a "con-

tinuous" or "performance" test, say for half an hour or an hour, the fatigue being estimated by the diminishing output during that period. One mental test of this kind consists in the addition of long columns of single figures, each successive pair of figures being added and the results written down, with a view to seeing how much work of this kind can be performed minute by minute. As the subject grows mentally fatigued, so the mental work curve of output may be expected to fall. Another similar test is a kind of proof-correcting, consisting in crossing out as many (say) e's in a minute, the number in each minute being recorded. McDougall's dotting test may be also mentioned, in which small circles, printed in irregular positions on a long narrow strip of paper, have to be dotted at their centre, while they pass, as in a telegraphic tape machine, rapidly before the view of the worker. These and other tests involving attention and precision have proved of value.

In all such tests, of course, the factor of practice enters; and where its effect is considerable (as in fact it nearly always is, even when the conditions of the test very closely resemble in-

dustrial conditions), the work curve actually rises instead of falling. Considerable practice in any test is therefore necessary, before it can be successfully employed as an index of fatigue.

In all tests there is noticeable an "initial spurt" when the subject starts fresh. A similar, but more voluntary, "end spurt" occurs towards the close of the test. An effort similar to that of an end spurt occurs when the piece of work given to the operative is of such a length that he can hopefully and confidently anticipate its completion. "Intermediate" spurts may also occur through unconscious or conscious influences. In the factory such spurts arise, *e.g.*, through an endeavour to make up for the delay previously caused by the non-arrival of material; especially when accompanied with annoyance at interference with the piece rate earnings, they may prove an important factor in subsequent fatigue. In the industrial curves of output, even a seventy-two per cent. increase in output observed during the last hour has been ascribed to end spurt; and as wage-days or holidays approach, a well-marked spurt is likewise generally found. In a certain munitions factory

the work of about one hundred women engaged in turning fuse bodies was observed to increase by from six to ten per cent. just before Christmas, but there was a fall of sixteen per cent. immediately after the holidays, although after a while the output rose to twelve per cent. above the pre-Christmas maximum.

This fall after a holiday is partly due to a further factor in the work curve technically known as "incitement." It occurs in the mental tests above described if the subject is taken away from his test even for two or three minutes. When he goes back to it, he has "grown cold," so to speak, and, like a machine, needs "warming up" again before he can get going as before. Allied to this is the factor of "settlement," the ability to settle down in spite of various distracting influences. Hence when a worker is taken away from his work for a while, he loses incitement and settlement, as well as practice; but he gains as regards fatigue, and he also gains because of the initial "spurt" with which a return to work is often accompanied. The well-known "Monday effect" has been shown to be due, not necessarily to dissipation

over the week-end, but to the loss involved in the matter of settlement and incitement.

It is, of course, to be expected that the curve of industrial output must vary considerably with the kind of work done. When the work involves merely strenuous muscular exertion we may expect a rapid and early rise in the work curve to a maximum, followed by a fairly definite fall during the morning spell, and after dinner a fair recovery followed by a progressive, well-marked fall throughout the afternoon. When, on the other hand, the work is characterized by skill and dexterity, we find a slower, more gradual rise to the maximum, followed by a less obvious fall, a less complete recovery after dinner, and a much smaller drop at the close of the afternoon. When, as in machine work, the output is largely independent of the human factor, the curve of output may be expected to reach a maximum at about the third hour of the morning spell, then to fall slightly, and during the afternoon to maintain so high a level that the output may exceed, or at least equal, the morning's output. Lastly, when, as in lathe machine work, the factor of rhythmic action is

added to skilled and strenuous movement, not only will the afternoon's output remain high, but also no fall may occur in the last hour of the day; while the morning output will start at a low level and increase enormously during the first three hours of work, falling towards the end of the morning less than in purely muscular work, but more than in merely dexterous work. We have already (p. 18) called attention to the economic, fatigue-saving effects of rhythmical action.

Clearly we are only on the outskirts of the vast realm of knowledge on this subject which awaits discovery. We now know that, *even in the resting state*, the human organism shows definite variations in efficiency throughout the day, such variations corresponding apparently to those in the normal curve of output under working conditions, though, of course, the output is at a higher level. Obviously, therefore, it is a thoroughly unscientific principle to set or to expect a constant rate of output throughout each hour of the working day. The effects of physiological fluctuations and of the influences especially of settlement, incitement, and fatigue,

must be taken into account. Otherwise at one time slackness, at another overstrain is encouraged. It also follows that since the output even in the resting state is lower towards the end of the morning or afternoon, we must be very cautious in our interpretation of the work curve, whether afforded by performance tests or by industrial output, as indicative of industrial fatigue.

Of the factors to be taken into account in industrial fatigue and in the maintenance of efficiency, one of the most obvious, in the past, has been the load a worker should lift or carry. Although in these days of increasing application of machinery, this factor is becoming of less importance, it is worth while to mention some striking investigations made some years ago on men who were engaged in loading railway trucks with pig iron. Each piece, or "pig," of iron weighed ninety-two lbs., and the men had been previously engaged on the work without any selection. It was found by experiment that, lifting pigs of this weight, the men should not be under load for more than forty-three per cent. of the day; that is to say, in a nine-hour day

the time under load should be three and three quarters hours. Accordingly the men were set to work for seven minutes, and after each such period they were given a rest of ten minutes. At the same time the expert selected his men, having noted that some of them (twelve and one half per cent.) were far better suited to the work than others. On this basis of work and rest and selection instructing the men how best to raise the pigs from the ground, how fast to walk, etc., he found that, instead of lifting, as they had done before, twelve and one half tons per day, they lifted forty-seven and one half tons per day (equivalent to about a three hundred per cent. increase in output), and that there was certainly no more fatigue involved than by the old method. In addition, wages were higher by sixty per cent. and there was a sixty-six per cent. reduction in the costs.

Another source of fatigue, as has been already noted (p. 17) is needless standing. This can often be lessened by arranging the workbench at a proper height, so that the employee may sit wherever possible, needless stooping being at the same time avoided.

Illumination must also be taken into account, both in regard to the abolition of glare from polished surfaces, and in regard to the opposite defect of too little light. The close connection between eyestrain, headache, and efficiency hardly needs mention. In a certain factory the lighting was increased from four thousand to twelve thousand foot-candles, and at the end of a month the output was increased by from eight to twenty-seven per cent., the only change being the better lighting. Yet at the present day in this country many operatives, *e.g.* silk weavers, are to be seen working in an artificial light, sometimes gas, even on the brightest days. It has conclusively been shown that miners' nystagmus, which consists in an involuntary tremor of the eyes, is due to the miserably poor light (often of a quarter- or a half-candle power) of the miner's lamp.

Noise is another factor causing wastage of energy and detrimental to maximal output. There is a case on record in which an increase of twenty-five per cent. in output was obtained by moving certain employees to comparative quiet, away from the noise of a yard. Despite its

well-known powers of adaptation to noise, the human organism works best under the most restful conditions. Vibration of machinery also well repays investigation in regard to its effect on the output of workers within its influence.

Ventilation, humidity, and temperature are important matters to take into account. Experiments have been conducted on animals subjected to different degrees of temperature and humidity, in order to observe the degree of exhaustion produced under the following conditions:

Temperature.	*Humidity.*
69° F.	52 per cent.
75 "	70 " "
91 "	90 " "

On the assumption that at 69° temperature and fifty-two per cent. humidity the work done was one hundred, it was found that as the temperature and humidity were increased as above, the amount of work done fell to eighty-five and seventy-six respectively. In recent investigations into the tin-plate industry, it has been calculated that at least twelve per cent. more output would be obtainable by efficient ventilation.

An obviously psychological factor which helps to increase output is security against danger. In dangerous trades, the workers show a tendency to neurasthenia. This is especially marked among coal miners; of the cases of nervous breakdown occurring during the late war, a disproportionately large percentage was found among soldiers who had been miners. Other obvious factors conducive to an increased output and to the reduction of fatigue are proper food, cleanliness, canteen and club comforts, library facilities, and other similar improvements now generally comprised in welfare work.

A great deal more investigation is required as regards the effect of continuous night-work. During the war it was found that the best effects of night-work in certain occupations were obtained if the workers did not work at night for more than a fortnight "on end," and were then turned over to day-work; but how far this result is generally applicable remains uncertain. There can be no doubt that night-work can never be really efficiently carried on, unless proper dormitories are provided for the night operatives so that they may be sure of getting a rest in the

daytime. It is possible without much difficulty to imagine the kind of sleep that an ordinary operative must get when he or she goes home to rest after night-work amid the social conditions under which most of the workers live. Again, nothing was shown more clearly during the war than the advisability of avoiding before-breakfast work and overtime. Even in peace time, before-breakfast work had been shown to be practically worthless; and as regards overtime, the worker simply "saved" himself during the day when he knew that he had to work late. This saving is largely involuntary, due to the organism physiologically setting up an unconscious defence against the prospect of excessive hours (*cf.* pp. 99, 100.)

A good deal of preliminary work has been done in the psychological laboratory towards determining what is the most favourable rest pause. It is clear that when all the various opposing factors influencing the work curve—practice, fatigue, spurt, incitement, settlement—are taken into account, there must be a rest pause of a certain length after a given period of work which will be more favourable to subse-

quent work than a pause of greater or shorter length. Work in the laboratory on this subject is being continued, and is capable of almost endless extension and of invaluable application to industrial problems.

In America some investigations have been carried out as to the effect of introducing a ten-minutes' rest in each spell of a ten-hour day. There occurred a three per cent. increase in output during the first period under observation, and this increase progressed during the second and third periods, when it reach seventeen and twenty-six per cent. respectively. (To this gradual increase of effect we shall return presently.) In a bleaching factory a twenty-minutes' rest was introduced after each spell of eighty minutes' work, whereupon a sixty per cent. increase in output was recorded, accompanied by a fifty per cent. increase in wages. In one of our own munitions factories, a fifteen minutes' rest was introduced after every forty-five minutes' work; the employees in this factory were paid by piece rate, and they grumbled at first at the enforced rest periods because they thought they would lose money through them;

but there was a very distinct increase in their output and consequently in their earnings. A five minutes' rest period introduced into every hour's work save the last, enabled a Lancashire firm employing girls to increase the daily output by 6.4 per cent. in one group of girls, and by 10.9 per cent. in the remainder.

Another interesting case on record is that of two rival groups of soldiers engaged in seeing which of them could dig the greater number of yards of trench at the front in a given time. The officer of one group divided his men into three sections, so that he was able to give each section ten minutes' rest after every five minutes' work. Thus one of the three sections was continually working in relays. The other officer worked his men in the ordinary way and employed no system at all; they dug their hardest until they were tired, rested for a spell and then dug again. The first group won easily, solely through the systematic rests which were introduced. The experiment has been since applied with similar success to bottlemaking, three teams (each consisting of a man and two boys) being employed for two machines, each

team working for forty minutes and resting for twenty minutes, so that one team was always resting. These results demonstrate the necessity for further investigation into the question of introducing rests. By enjoying a regular and definite rest period, the workers avoid fatigue, and the work lost during the rest period is more than made up by the increased output which they produce after each rest. At the same time something must be lost in the process of "warming up" or "incitement" after each rest period; and it is only by careful investigation of the figures of output before and after, and by experimentally varying the time of introducing the rest period and its length, that reliable information as to the best procedure can be obtained.[1]

With regard to the effects of reduced hours, some striking results were obtained in our own munitions factories. In the case of men engaged in the heavy work of sizing fuses, which is dependent solely on their own efforts and independent of machinery, the hours actually

[1] Moreover there can be no doubt that different individuals demand different treatment, some, for example, working best in short explosive "bursts," others in longer steadier spells.

worked were reduced from 58.2 hours to 50.6 hours per week—a reduction of about thirteen per cent.—with the result that the hourly output was increased by thirty-nine per cent. But hourly output is not of so much interest to the employer as the total output; here the total output was increased by twenty-one per cent. A reduction in hours from 63¼ to 54 per week was found approximately to halve the lost time due to irregular attendance. In the case of women engaged in the moderately heavy work of turning fuse bodies, which is partly dependent on the speed of machinery, the hours were reduced from 66 to 48.6 per week—a reduction of about twenty-six per cent.—and the result was a sixty-eight per cent. increase in hourly output and a fifteen per cent. increase in total output.

In a tin-plate factory the introduction of a six-hour shift increased the hourly output by 8.3 per cent., and the introduction of a four-hour shift increased it by 11.5 per cent., as compared with the hourly output of an eight-hour shift. In an iron works the reduction of hours from fifty-three to forty-eight per week

reduced lost time from 2.46 to 0.46 per cent. of working hours.

Two apple-growing estates in Australia, separately managed by two brothers, received a large and urgent order. Their staffs were paid by piece rate. One of the brothers kept his employees working as before at eight hours a day, whereas the other's staff asked to be allowed to work ten hours a day. At the end of a week the daily output of each worker of the former's staff averaged from five to six cases of apples more than that of the latter's.

In a bicycle-ball factory in America the hours of work in detecting defects in the balls manufactured were reduced from 10½ to 10 per day, and then by successive steps to 9½, 9 and 8½ per day. Although the daily rate of pay remained constant as each reduction in hours took place, the output was found to increase.

Careful observations have proved that the *full* effects of reduced hours of work may not be manifest until several months have elapsed. Alteration in hours influences the unconscious, as well as the conscious, factors that determine

output. The human organism, after becoming adapted to certain hours of work, requires time, when that adaptation is disturbed, before it can give its maximal response to improved conditions (*cf.* p. 62). It appears that when such *gradual* adaptation to improved conditions is effected, if the old conditions be then restored, the output *immediately* reverts to its previous amount. If this statement is confirmed by further investigations, it shows the fallacy of introducing overtime work, as apparently another long period of adaptation is needed after overtime has been abolished.

The advantageous effects of rest periods and of reduced hours are most clearly manifested when the work involves the "human" factor most. If it is mainly dependent on machinery which moves at a fixed unchangeable rate, clearly any improvement in the freshness of the workers cannot so materially affect the output. But even here it will reduce the quantity of spoiled work, and it will effect improvement in the worker's attention and hence in the speed of feeding of, and in the rate of removal of the manufactured product from, the machines.

Much, of course, must depend on how any increased period of rest is spent. A ten-minutes pause may be profitably occupied in taking light refreshment. An hour's earlier release from a factory or business may wastefully result in an hour's more exacting, worrying, or harmful occupation elsewhere.

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CHAPTER III

SELECTION STUDY

Genius and talent—Excessive labour turnover—Individual differences—Vocational guidance—Reaction times—Tests of telephone operators—Other mental tests—Physical and sexual differences—Army, Air Service, and Admiralty selection tests—"General impressions"—"Phrenological" and physiognomic tests—Classification and use of mental tests—Blind-alley and unsuitable occupations—Pre-vocational and vocational training—The future of vocational guidance and selection.

CHAPTER III

SELECTION STUDY

SOME people, *e.g.*, distinguished inventors, ministers, painters, poets, musicians, have been driven to take up their calling because of the irresistible impulse of their *genius;* but most men and women are gifted only with *talent*, which permits of a certain choice of occupation. Of the latter some, of course, choose occupations for which they are best fitted. But many, subject perhaps to the advice of friends and relatives, are apt to choose the wrong occupation. Some act merely on tradition, following the occupation of their father and grandfather. Others are actuated by expected influence, or are attracted by interest and imagination to occupations (*e.g.*, to the stage, the sea, or the army), for which they have no real aptitude. With these various and often detrimental factors at work, it is hardly surprising that an enormous

wastage of effort and expense arises through people choosing the wrong occupation. It was astonishing during the war, when inquiring of men what they had done in civil life, to discover how many had passed from occupation to occupation until they had at length found something which suited them. Even within the compass of a single mill or factory, operatives will not infrequently wander from one department to another until at length they find the job that really fits them. This wasted effort seriously affects the employers also, for the amount of time thus thrown away in training workers is needlessly great. In a munitions factory in the United States, it appears that during six months only ten per cent. of ten thousand employees who left the works left for reasons known to the employers. This occurred during the war; but in proof that such wastage is not confined to the war period, the pre-war statistics of a munitions factory in this country may be quoted, in which it was found that of one thousand women entrants into the firm, 658 left after six months. During the war this figure rose only to 671. A fifty per cent. turnover of women labour is

indeed not uncommon, and even three hundred per cent. has been recorded in the year.[1] Among women the factors of marriage, sickness, and maternity are largely responsible for a big turnover. A highly important factor determining such wastage in both sexes consists in unsatisfactory conditions of employment; but the special cause to be considered in this chapter is the unsuitability of the workers for the particular work they adopt, together with the remedy for it.

For each individual, it may be said, there is one occupation which is more suitable than any other, and in every occupation some succeed better than others. This arises from the wide physical and mental differences distinguishing individuals from one another. For example, in some the constructive instinct, in others the acquisitive, in others again the submissive instinct is paramount. Some are predominantly of the hunting type, others are rather of the pastoral or agricultural type, with appropriate

[1] That is to say, in order to maintain a staff of one hundred at its full strength, three hundred employees had to be engaged during the year.

instincts of aggressiveness, tenderness, etc., peculiar to each. Individuals also differ innately in manual dexterity, span of apprehension and memory,[1] etc. Thus in a pencil factory, where twelve pencils have to be picked up from a pile with one hand, some fail after many attempts, while others are successful at once; and in a printing establishment, some linotype operators never pass beyond the 2500-em class (the em being a measure of output), whereas others, with no great effort, can manage, it is said, to set five-thousand ems.

Obviously much can be done to prevent the "round peg" from getting into the "square hole" by means of vocational guidance offices for lads and girls on leaving school. A great deal could be effected there merely by sympathetic interviews aided by school records and knowledge of the special requirements and openings in different occupations. Such a procedure would at least help in coming to a broad decision as to whether a given boy or girl

[1] Span of apprehension is measured by the number of different objects which can be simultaneously perceived upon momentary presentation; span of memory by the number of objects retained after a single non-momentary presentation.

is better fitted for mental work or manual employment, for indoor work or outdoor work, for a settled or a roving life, for direction or dependence, etc.

But the scientific study of vocational guidance must be founded on something more than "general impressions" (undeniably valuable though they be). It must undertake a careful physiological and psychological analysis of (i) the requirements of different occupations, and (ii) the individual mental and physical differences among those intending to work at them. For the groundwork of the latter task, and for methods of procedure, we are indebted to the experimental psychology of the laboratory. Some of the earliest psychological investigations, those on reaction time, were devoted to a study of the nature of the individual differences observed. It was found that, when instructed to react as rapidly as possible to a prescribed signal, some persons were naturally of the quicker, less reliable, so-called "muscular" type, attending predominantly to the movement by which they had to react, while others were naturally of the slower, more reliable,

"sensorial" type, attending predominantly to the signal which they were expecting to receive. The advantages of choosing employees for certain occupations according to their reactions have been shown in a certain bicycle-ball factory (to which reference has been already made on p. 66), where after the selection of the best workers on the basis of reaction tests, it was found possible to increase the output by over 240 per cent. and to increase the accuracy of the work by two thirds.

Similar success has followed the application of other psychological tests, *e.g.*, in the selection of applicants for telephone-exchange work in the United States. It is obvious that acuity of hearing, clearness of speech, ability to interpret indistinct words, span of memory for figures, memory for the order of instructions received, speed and dexterity of reaction to signals, are all readily capable of experimental estimation, and that the tendency to nervous breakdown in such a trying occupation can be largely avoided by the selection of suitable applicants.

Psychological tests of foresight have been applied in investigations upon motor-tram

drivers. A close inverse relation has been found to obtain between the degree of a driver's success at the laboratory tests and the number of accidents recorded against him during his everyday work. The value of such investigations needs no comment.[1]

Tests of the accuracy and speed of reasoning have also been devised. Tests of general information have been frequently employed. These and other tests are now introduced into Columbia University, New York, as an alternative for the matriculation examinations, so as to select those who can best profit by a University career.

Among other available tests may be mentioned those of sensory discrimination, manual dexterity, mechanical skill, æsthetic appreciation, rate of reading, spelling ability, tests which reveal the subject's special interests, his muscular or mental fatigability, his accuracy, steadiness, and neatness, his memory for names, figures, faces or facts, the breadth or detail of his observation, his improvability, distractibility,

[1] Care, however, must always be taken that the test is one of special ability, not of general intelligence.

suggestibility, etc. Their application to those who offer themselves for different occupations, *e.g.*, for machinist's or assembler's work, designing, clerical or secretarial work, salesmanship, etc., is obvious.

On the physical side, tests of muscular strength and endurance are of great importance for certain occupations. Length of arm reach, and the span and shape of fingers may be likewise of value; in one industry, for example, it has been stated that an increased output of from six to over nine per cent. may be expected by taking such factors into account in the choice of girls for the different departments. Again, in regard to sexual differences, it is clear that there is great scope for research by appropriate tests to determine the occupations which are best fitted to men and to women.

Tests have been devised to measure the worker's rate of feeding a machine, and success in these tests has been proved to be correlated closely with the known fitness of the worker for a fast- or a slow-running machine in the factory. The value of such tests for selection is confirmed by the observation that some workers who are

distinctly below the average on a slow operation may be very much above it in work requiring speed, and *vice versa*. Certain tests which have been applied to measure dexterity and rate of assembling have been found to be closely correlated with workshop ability, and sometimes indeed have proved the foreman's original estimate of the workers' ability to be wrong, as his judgments agreed far more closely with the results of the tests after he had come to know the workers more intimately.

During the war such psychological tests were developed with great success. In the United States a staff of experts was engaged (i) in applying tests for estimating the educational level and intellectual ability of each recruit, (ii) in recording the men's pre-war experiences and in devising and applying appropriate tests to prove their special qualifications, and (iii) in devising and applying tests for the selection and training of telegraphists, gunners, and others. Among the objects of the first of these groups of tests were (*a*) the allotment of a mental rating to each soldier, so as to help the personnel officers in the formation of organizations

of equal or of appropriate mental strength, (*b*) the assistance of regimental company and medical officers, rendered by careful examination and report on men who were not responding satisfactorily to training, who were otherwise troublesome, or who, in accordance with their degree of mental deficiency, should be recommended for discharge, development battalions, labour organizations, etc., (*c*) the discovery of men of superior ability who should be selected for non-commissioned officers, for officers' training camps, for promotion or for assignment to special tasks. It is generally agreed that such tests saved many months of needless camp life and that by means of them the right man was far more often put in the right place.

During the war certain candidates for our own Air Service were tested carefully from the psychological aspect before they were finally accepted. Their vision was examined as regards stereoscopy (the perception of objects in relief) and the rate of adaptation of their eyes to darkness. They were also tested for their speed of recovery of their balance by manipulating lever-movements when the seat on which

they were placed was tilted. Tests were also applied to ascertain how faint a sound they could hear, and how accurately they could localize it—abilities which were important in listening for hostile aircraft. The result of these and many other psychological and physiological tests was to effect an enormous improvement in the class of men selected for special training.

Similarly successful work was also carried out for our Admiralty at the Crystal Palace in the selection of candidates for training in hydrophone-listening for hostile submarines. Appropriate tests were devised for keenness of hearing, accuracy of sound discrimination, memory for pitch, rhythm and quality of sound, power to discriminate between different pitches, rhythms and qualities, general accuracy, general information, ability to grasp complicated instructions, etc. The result of the application of these tests was that the training authorities at Portland reported that the first batch of lads thereafter sent them from the Crystal Palace was far away the best they had ever received, and that the next batch was even better still!

Many of the mental characters hitherto mentioned can be readily and speedily tested on *groups* of fifty or more persons simultaneously. But an objection may be raised that such tests throw no light on the higher, moral qualities of the candidate, such as honesty, courage, loyalty, perseverance, promptness, punctuality, resourcefulness, imagination, organizing ability, self-control, and presence. In point of fact, however, several of these qualities are revealed by many existing tests or by others that can be devised for the purpose, whilst full light can be readily thrown on the rest in the course of individual examination and cross-questioning. None but those who have had experience in psychological tests can realize what a wealth of information in regard to the general "character" of a subject is incidentally gained from a few tests systematically and *individually* applied during an interview.

Indeed the object of these tests is not to replace, but to supplement, the "general impressions" which an interview can afford. Their application to a group of people simultaneously is often unsatisfactory for the very reason that it

does not permit of adequate individual observation and conversation. Such information, however, as is afforded by general impressions is apt to be too "general" to be of sufficient use. Loyalty, perseverance, and punctuality, for instance, may be required for a variety of different occupations; an ordinary interview may detect them, but it will not detect the more special abilities or determine whether the candidate is more suited for one department of the works rather than for another. Our general impressions are formed intuitively from a variety of often more or less unconscious influences, dependent on facial expression, speech, bodily movements, dress, etc. Attempts have been made of late to reduce such impressions to an exact science, based on the shape of the candidate's face and head, the colour and prominence of his eyes, the texture and colour of his skin, etc. But they are devoid of scientific basis. The mental characters of an individual are not associated, *e. g.*, with the form of his brain, and the form of his brain does not exactly correspond with that of his skull. To act on the teachings of this "school"—for instance, that aggressive-

ness, quickness of action, cheerfulness, and fickleness are characteristics of the blonde, that submissiveness, slowness of action, pessimism, and constancy are characteristics of the brunette, that logical people have high narrow foreheads and sloping shoulders, that ambition is associated with height of head, energy with an elastic skin, with a long high nose, and with width of head, impulsiveness with a receding chin—can only result in failure.

General impressions are notoriously unreliable, besides being, as already explained, insufficient. The object of psychological tests is, so far as possible, to substitute scientific methods of *universal* validity in place of *individual*, intuitive, often capricious and prejudiced opinions.

Enough has been already said of these tests to indicate that they may be classified under two heads. On the one hand, we may adopt a test which is more or less exactly comparable to the conditions under which the subject will be working; *e.g.*, we may test his powers of typewriting by actual typewriting, we may test his ability to assemble a machine by giving him

some parts to put together, or we may supply him with an apparatus which will compare with the rapid feeding of a machine. On the other hand, we may test him for isolated mental characteristics, *e.g.*, dexterity, speed of reaction, span of apprehension, appreciation of differences in visual form, and we may utilize and combine the results of his various performances in the following way. First of all, we ascertain what special psychological processes are required for success in the occupation for which the tests are needed. Next, we ascertain how closely success or failure at the tests which we have devised in order to measure these processes is correlated with known success or failure at the occupation in question; that is to say, we compare the order of excellence of a large number of trained (good, bad, and indifferent) operatives at each of the tests with their order of excellence in the workshop as determined by the estimates of foremen, by piece-rate earnings, etc. Then we proceed to "scrap" the tests which show insufficient correlation and we "weight" the useful tests according to their different proved degrees of correlation. Finally, we are able to apply the

tests to the actual examination of candidates whose capacity for the work we are desirous of estimating. By this means the relative, as well as the absolute, value of each test is accurately ascertained before it is employed in actual practice, and the likelihood of the candidate's success in any particular occupation can be expressed in the well-known quantitative terms of probability.

It is clear that central laboratories coordinated by a National Institute of Applied Psychology and Physiology are needed in order to devise tests and to collect standards. Standards or averages are clearly necessary in order to discover to what extent a given person departs from them. In such laboratories it will be necessary to train testers, to advise "educationists," employers, and trade unions. This is only a step towards having psychological laboratories in the larger factories, and in advisory bureaus connected with labour exchanges and employment committees, where employees and lads and girls leaving school can be adequately examined, tested, and advised, in regard to their fitness for different occupations.

Such central laboratories will be concerned with the investigation not only of human beings in their relation to vocations, but also of vocations in their relation to human beings. There are many occupations which cannot be called vocations at all. They are "blind-alley" occupations, involving no craftsmanship and offering little or no chance of variety or promotion. Into these boys and girls, on leaving school, are specially prone to enter, tempted by the relatively high wages which are offered them, and heedless of the future when they will have to leave that employment and swell the ranks of unskilled workers. There are other occupations that have no right to exist—for example, the lowly work of carrying heavy loads which can and should be performed by machinery.

It will also be the duty of a National Institute to encourage the provision of what has been termed "pre-vocational training" in the highest standards of our elementary schools. By their fourteenth year boys and girls should have received special instruction at school, illustrated by lantern slides, etc., in the demands, attractions, dangers, and rewards of the chief avail-

able trades and professions, so that they may be better enabled to make their ultimate choice, instead of aimlessly accepting the "first job that comes along." Vocational guidance must also be encouraged during the period of continuation schools, at the "works" or outside, due regard being paid to the development of special tastes or capacities after the school-leaving age.

In these ways the future application of psychological methods and principles to vocational guidance and selection cannot fail to yield results of inestimable value for the advance and well-being of mankind. Because tests are in their youth, it would be ridiculous to urge that therefore they must be put aside until they reach fuller maturity. We might as well have banned surgery and medicine a hundred years ago because they had not then reached their present stage of advancement, or ban them to-day because they are not so efficient as they will be a hundred years hence. Applied sciences can grow only by use. Their success must largely depend on the skill with which they are applied. Like any other instruments which man employs, they may be rightly or wrongly

used; but this does not mean that vocational selection is unscientific. Medicine or surgery might as well be similarly decried because of their dependence on a judicious application by the physician or the operator. Judgment and intuition are just as essential in the use and interpretation of vocational tests. Tests are not to be regarded as the master, but as the servant, of such valuable "general impressions" as may be gained by a conversational interview. They bring to light special abilities which a mere interview is powerless to elicit or to measure. They will be viewed with disfavour by the employee who fears that, if he be found unsuitable for his present work, he may be transferred to lower or less congenial forms of employment or be thrown out of employment altogether. Such fears are reasonable (*a*) where vocational selection is forced upon an already engaged employee, instead of on an applicant for employment, (*b*) so long as the worker is not guaranteed against unemployment through no fault of his own, and (*c*) until he is given some voice in works management. Vocational tests will be viewed with disfavour by the foreman

who has been selected merely for his driving power, who is an ignorant man, scarcely capable of speaking, reading, writing, or thinking intelligently, who is hence suspicious of higher ability among those under his charge and only willing to recommend men of his own stamp for promotion. They will be viewed with disfavour by the employer who is opposed to the introduction of the systematic methods of science, who prefers to be ruled by guesswork and intuition or by the long and wasteful process of trial and error. Vocational guidance and vocational selection have, therefore, a brilliant future before them.

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CHAPTER IV

RESTRICTION OF OUTPUT

Restriction by the employer: deliberate; unconscious —Restriction by the employee: deliberate; unconscious—Examples of employees' restriction of output —Methods of detection—Artificial uniformity of output—Need of efficiency records—Coal output—Bricklaying—American and British productivity—Effects of increased use of machinery.

CHAPTER IV

RESTRICTION OF OUTPUT

OUTPUT may be restricted by the employer or by the employee; either of them may restrict it deliberately, or more or less unconsciously.

Deliberate restriction of output by the employer may come about through at least three causes, viz., (i) the dearth of raw material, (ii) the fear of flooding the market, coupled with the desire to maintain an artificially high price for his manufacture, and (iii) the need for co-ordinating the requirements of different departments of his factory. More or less unconscious restriction of output by the employer may arise (i) through bad organization and out-of-date equipment of his factory (*cf.* pp. 5–7), (ii) deficient training of his employees in the best methods of work (*cf.* pp. 8–15), (iii) ill-considered arrangements of the working hours (*cf.* pp. 64–67), (iv) inadequate rest pauses (*cf.* pp. 61–64),

and (v) defective selection of his employees for the task for which they are best fitted (*cf.* pp. 73–75).

The prime causes of deliberate restriction of output by the employee at the present day are discontentment, suspicion, and jealousy (*cf.* Chapter VI). An important cause also lies in the fear that with increased output the scale of piece-rate or task-rate payment will be reduced. The rate has been not infrequently cut when men begin to earn more than the employer had thought possible when setting the rate. There is a good instance on record of a girl paid by piece rate, who was shown by a passing expert a more efficient method of working by which she could earn far higher pay. Later, however, she was found to have returned to her old method, and the reason she gave the expert was that she knew her employer would cut the rate if his girls earned more than a certain sum per week. A worse example—indeed one of almost unparalleled industrial barbarity—has been recorded in the United States, where a bonus of twenty-five per cent. was paid if a job was completed in a set time. A special bonus was at the same

time given by the employer to the time setter, this bonus being based on the number of workers *failing to earn* the bonus, so that the more workers who failed to earn the bonus, the larger the bonus for the time setter. Consequently the time setter set so short a time for the job that very few workers could earn the bonus. A further refinement in cruelty was introduced, the foreman being given a special bonus on the number of men who *earned* the bonus. Thus the workpeople, while given a task by the time setter so severe that few could do it, were at the same time driven by the foreman to do their very best at this almost impossible task.

Although such extreme cases have not occurred in this country, yet there are many instances—far more numerous than is generally supposed—in which the rate has been cut here, and it is undoubtedly an important cause of the deliberate restriction of output by the employee. One of the absurdest cases on record occurred where the earnings were originally based on the performance of a certain task in five hours. The workers finished it in four hours, whereupon the time rate was cut to four hours. The

workers then managed to finish it in 3½ hours, whereupon the time rate was at once cut to 3½ hours. The workers then finished the job in three hours, and the time rate was further cut to three hours. But by this time the workers had learned wisdom. They now took seven hours for the job. The time rate was raised to four hours, but without effect, then to five hours; whereupon the workers finished the job in 3½ hours. Once again the time rate was cut, and once again the job took seven hours to accomplish!

The remedy for such senseless warfare is perfectly obvious: systematic investigations in time study must be conducted at the outset with the approval and co-operation of all concerned, so as to fix a fair piece or time rate, satisfactory to all concerned, which will honestly be maintained so long as the working conditions are not materially changed.

Another cause of deliberate restriction is the fear of disloyalty to less capable fellow-workers. This can only be safeguarded (i) by the establishment (based on scientific study) of a recognized range of individual differences of output,

within which workers may feel secure in their employment (*cf.* p. 123), (ii) by a proper selection of workers at the outset according to their special abilities, and (iii) by a guarantee against loss from unemployment when arising not through any fault of the worker.

It may here be pointed out that the restriction of output by workers has been shown in the United States to occur in what are there called "open shops," *i. e.*, where there is no trade unionism, as well as in shops where the men are members of a trade union. Restriction of output, therefore, is not limited to trade unionists.

Output is unconsciously restricted by workers as the result of a physiological process of adaptation, protective against undue fatigue at the end of the day. The worshipper in church or the child at school cannot be expected to give unremitting attention to his prayers or lessons; the shorter the period of his attendance, automatically the better maintained will be his attention over that period. So, too, the worker unconsciously proportions his efficiency to the length of his working spell or shift. It is owing

to changes in such unconscious adaptation that reduced hours have so often yielded as great an output as was obtained before reduction, or even an increased output (*cf.* pp. 64–66). The unconscious nature of this process is doubtless indicated by the fact that the reduction in working hours may not show its full effect until many weeks after the change (*cf.* pp. 66–67). Such delay would not occur if previously there had merely been a deliberate restriction in output. Shorter hours do not owe their beneficial effects to increased spurts. Beyond certain limits, spurts, like drug stimulants, are in the long run harmful to efficiency. Riveting competitions and the like, where work is carried out under abnormal conditions of volitional tension, yield no information whatever of the proper daily output that may be expected from the worker, nor of restricted output.

More or less unconscious restriction of output by the workers also arises from general slackness on the part either of management or labour, from tradition ("it has always been the custom to turn out so much"), or from the general factory routine which would be disturbed if an

increase in production occurred in any one department.

A few examples of undoubted restriction of output by the workers are here given. Night after night in a munitions factory of the United States the output of sixteen women drilling holes was found to be 3600 precisely. If the machines stopped for any reason, they evidently put on a spurt afterwards, because the output remained constant over the period of examination; indeed, it was found that this spurt was capable of effecting a temporary increase of from seventy-five to ninety per cent. (elsewhere even from 136 to 142 per cent.) in speed of production. In another instance, six women were gauging fuses. Five of these women, day after day, gauged 1315 fuses exactly. A man, whose output was observed for forty-five nights, while employed in an operation on fuses, finished, save on one night, exactly one thousand fuses per night, while three others, similarly employed, turned out this number on forty-seven nights out of fifty, forty out of forty-nine, and forty-six out of fifty-one nights, respectively.

In the shops of a certain factory in this coun-

try, five thousand of a certain article were produced weekly. The management decided to open a new shop, in which the mechanical conditions were practically the same as before, excepting that inexperienced operatives were engaged, who were unfettered by tradition, knowing nothing about the work. At the end of six months' practice this new shop produced thirteen thousand of the articles per week, whereas each of the older shops, with its restriction of output, continued to produce only five thousand.

Another case on record concerns six units of machinery, each of which produced 2500 articles per week, the total output being therefore fifteen thousand. It was decided to remove some of the machinery, unit by unit, to another factory, and at the same time to give a bonus on output to the workmen on the remaining units. When the first unit was removed, the total output of the remaining five still kept at fifteen thousand per week; when the second, third and fourth units of machinery were successively removed, the total output of the remaining units nevertheless reached fifteen

thousand per week—a final increase in output of two hundred per cent. being thus attained.

A valuable method of detecting restriction of output is to take the average output of a number of workers on the same job over a determined period, and to observe to what extent the output of individual workers falls short of or exceeds this average. Excessive uniformity of output among different workers thus compared is a sure indication of restriction. The forms of the individual daily work curves showing the output during each consecutive hour of the day, are also highly instructive. If the output rises considerably during the last few hours of the day, there is good reason (apart from the effects of end spurt, *cf.* p. 52) to suspect that there has been restriction earlier in the day. At the same time, it is difficult to lay down any general rules as to the effects of restriction on the work curve of different individuals. While some workers may prefer to restrict their output earlier in the day and to make it up, if necessary, towards the close, others may push hard at the beginning of the day and slacken towards the end. But any such departures from the normal

will generally be revealed by a systematic study of the individual curves of hourly output.

Where several workers contribute jointly, by team work, to a given job, there is apt to be uniformity and restriction of output. This is especially likely to be the case (i) when a flat uniform day rate is paid, or piece rate earnings are shared by the team, in a prevailing atmosphere of discontentment or want of interest, or (ii) when a uniform task is exacted throughout each hour of the day. In one such works the daily output was fixed at one hundred items, and during each hour of the day a constant output was maintained. The daily curve of hourly output was therefore a straight line. This purely artificial condition, imposed on the workers by the management, may have involved undue effort at the beginning and end of each spell, but it almost certainly provoked some restriction of output during the middle hours of it, for no one can maintain a uniform output throughout the day under natural conditions.

Uniformity of output among different workers is certain to occur where an excessive number of men are engaged in team work upon a job. A

case of this kind is on record where men employed in loading coal at one centre were paid a certain rate, while those engaged at another centre on similar work were only being paid two thirds of that rate. Seven men left the latter centre to go to the former because of the higher rate there, but in two months' time they returned, saying that they could not earn so much money at the higher rate on account of the slackness prevailing through the large number of men employed on each truck.

The value of hourly and daily curves of output has already been emphasised. Efficiency records should be kept of every machine, showing their variability according to the particular machine, the quality and supply of material, and the skill and experience of the operative. Records of this kind, carried out in a Yorkshire cloth mill, have shown that the average production per loom per annum (allowance being made for cleaning time and for serious stoppages) was only 53⅜ per cent. of its possible efficiency; for shorter periods and for different materials, the efficiency varied from seventy-five to eighty-six per cent.

In many cases it is impossible to determine how far the management or the workers are responsible for such restriction of output. It is obvious that where machinery and transport are deficient, or where employment is irregular and spasmodic, the mentality of the workers must be affected adversely. In the coal mining industry, for example, the yearly output in tons per employee in the United States has been given as 400 in 1887, and as 660 in 1912, rising to 900 during (the spring of) 1919. In this country, on the other hand, the figures are 312 for the year 1887 and 244 for 1912. Correspondingly, the monthly output in this country is given as 19.4 tons in 1916 and as from 15.4 to 14 tons for the summer of 1919. There is, naturally, no agreement between mine owners and miners as to their respective shares of responsibility for this progressive reduction in output. But in making comparisons it must be remembered that the methods of coal mining in the United States and in this country are far from being really comparable. In the former the seams are thicker and more accessible, the mode of working is much more wasteful, and

there is about half the number of workers above surface in proportion to those below, as compared with this country.

Between wasteful working, spoilt work, and restriction of output it is difficult to draw any hard and fast line. An estimated saving of £100,000,000 could be effected in this country by the standardisation of wagons and locomotives, by the establishment of centralised coal depots and electric supplies, by the substitution of electric traction for steam locomotives, by the elimination of purely wasteful competition and overlap, by increased factory specialisation, and by the proper utilisation of the waste products of coal consumption.

Another instance of lessening output in Great Britain is afforded by the number of bricks laid in plain walling per worker per day. In 1885 the number was from 1200 to 1500 per day (the men being paid by piece rate); but in 1912 it had fallen to from 500 to 600 per day, and by 1920 to 300 or less per day. This reduction is largely due to the unsatisfactory conditions of employment in this industry. Under the most favourable conditions as revealed by

scientific motion study (*cf.* p. 15), it has been found possible to lay 350 bricks *per hour!*

According to the British and American censuses of production for 1907, in twenty-six leading trades there are roughly four British to five American wage earners. Yet the total production of the two countries is as 1 : 2.64, the horse power they employ is 1 : 3, and the value of output per wage earner is as 1 : 2.1. Such differences are mainly due to bad organisation, restriction of output, and to deficient supply or abuse of machinery.

As an example of the abuse of mechanical contrivances, the fact may be cited that in most engineering shops steel cutting-tools of very different qualities are to be found side by side, and often indistinguishable from one another, despite the enormous difference in their cutting speed. The best carbon tool steel has been found to have a cutting speed only one fifth of that attainable by the best heated air hardening steel; soft steel can be cut one hundred times as fast as semi-hardened steel or chilled iron.

Output can be enormously increased by making fuller use of machinery. It has been

just pointed out that the United States uses three times as much power per worker as we in this country. To give another instance, fifty per cent. of the coal mined in America is cut by machinery, as compared with eight per cent. in Great Britain. Although, as has been already indicated, coal cutting in America and Great Britain has been run on very different lines, it is difficult to resist the conclusion that a great deal more could be done towards increasing the output by the greater use of machinery in this country, and towards relieving mankind of occupations which are so monotonous or so uninteresting that they are only fitted to be performed by machinery or by beasts of burden.

In the production of yarn, it has been calculated that twenty-five men and fifty boys now produce by machinery the total amount of yarn which was produced by hand two hundred years ago, the present working hours being from six to seven less per day. The introduction of machinery into the cotton industry has produced remarkable results in increased employment. Before the times of Crompton and Arkwright, there were, it has been stated, only

8000 operatives in the British cotton industry; twenty-seven years later there were 300,000; eighty years later there were 800,000; and if those engaged in machine manufacture in connection with the industry are included, about 2,500,000 workers are now engaged in it.

Unfortunately most workers hold the view that the introduction of machinery must necessarily involve reduced employment, and it is often overlooked how the wider spread of motor cars, bicycles, gramophones and many other things—simply because, owing to improved machinery, they are now made more cheaply and in far greater number—has led to increased employment. The reduced cost at which such articles can be obtained is in itself an equivalent to increased wages, and their more general use by the community results in a higher standard of living.

The opposition of workers to the further introduction of machinery may be also considered by inquiring what would happen if, instead of increasing the amount of machinery, we reduced it. The cost of hand-made goods would rise to such a prohibitive figure that few

could afford to buy them; factories would therefore close down, and the small market available could only be met at the cost of a large reduction in wages. Nevertheless, the *immediate* effect of reducing machinery would result in a demand for an increased number of workers. So too, conversely, the immediate effect of increasing machinery must be to throw a large number of workers out of employment. When, for example, the linotype was first introduced, many compositors were reduced to a condition bordering on starvation, although later, of course, the number of workers required with the spread of cheaper printing was enormously increased.

.uch fears of temporary unemployment, well grounded as they therefore are, can only be met by a guarantee against loss of wages when it thus occurs through no fault of the worker. Otherwise there must always be vigorous opposition to the introduction of improved mechanical devices leading to increased output. Objections will still be raised that the increased output is attained at the cost of good workmanship and with a loss of human interest in the work. But the consideration of this last factor

must be reserved to a later chapter (Chapter VI).

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CHAPTER V

SYSTEMS OF PAYMENT

Time rate and output rate—Opposition to payment by results—Differential piece rates, premium and bonus systems—Scale of recognised individual differences in output—Advantages of and objections to day rate—Graded day rate—Collective piece rate and bonus — Profit sharing — Co-partnership — Present tendencies.

CHAPTER V

SYSTEMS OF PAYMENT

FROM early times two systems of payment have existed; the worker being paid either a fixed time rate for his toil, or a variable wage according to his output. These two systems have continued to this day, despite the profound changes wrought by the introduction of machinery and by more complex factory and business organisation. They have, however, been subject to various modifications and complications, usually in attempts to combine the advantageous features and to abolish the drawbacks of each.

The majority of employers and, perhaps, of individual workers in this country prefer the system of payment by results to that of payment by day rate, the former because it affords a stronger incentive to increase of output and facilitates recognition of the more industrious

workers, the latter because, under fair conditions, it is capable of yielding higher wages. Nevertheless, certain employers, many workers, and some of the most important trade unions (*e.g.*, those concerned in engineering, building, and woodwork) are strongly opposed (through past, often unfortunate, experience) to payment by results. They urge that this system creates suspicion, selfishness, and dishonesty in the factory and that it lowers the quality of the output. Doubtless, with increased care and supervision, these dangers may be to some extent overcome; but, carelessly introduced, these remedies may in themselves react injuriously on the mental atmosphere of the worker. Under the system of payment by results, the worker is apt to think himself regarded as a piece of machinery, revolving so many times a minute and capable of being driven still faster with the prospect before him of increased earnings. He may prefer a uniform rate of payment which is less dependent on fluctuations in his health and energy or on periods of good and bad trade. For these reasons a guaranteed minimum day rate should be combined with payment by results.

Payment by results has also been opposed by the worker on the grounds that those who show the possibility of increasing output become unpopular with their less efficient or less industrious comrades, and that increased output has often resulted in a repeated lowering ("cutting") of the piece rates (*cf.* pp. 96–98), sometimes through sheer greed and unscrupulousness on the part of the employer, sometimes through a fear of the results of excessive wage earning, to which we shall presently again refer. Hence a general demand has arisen (i) that the workers shall be assured that a piece rate, once established under given conditions, will not be lowered unless those conditions are admittedly so changed that the work is performed more easily and rapidly than before, (ii) that the weaker workers shall be guaranteed against unemployment, and (iii) that no worker shall suffer loss of earnings through hitches arising from defects in raw material, tools, or machinery over which he has no control. With these demands unsatisfied, it is not surprising that in some instances the introduction of piece-rate systems has resulted in reduced, instead of in

increased, output; the workers' aim being to restore the day rate which assured them a definite wage, and their lack of ambition or their corporate spirit overcoming any desire for individual independence.

Other things being equal, the employer can really afford to pay his workers a higher rate as their output increases, for the same overhead charges are now spread over a larger quantity of manufactured articles and so the cost of production becomes materially reduced.

To avoid subsequent rate-cutting, the employer has come to recognise that before a rate is fixed, he must have accurate knowledge of the output which a normal man should produce. He is beginning to realise the unreliability of hidebound tradition, purely theoretical calculation, rapid guesswork, or an ill-trained foreman's estimate. Accuracy can only be attained by time study systematically applied (and reapplied at necessary intervals) by expert investigators with the consent and co-operation of all concerned. Only by this means can collective bargaining, as it has been termed in the past, be placed (and maintained) on a scientific basis,

and open dishonesty abolished on the part both of employees and employers in regard to output and earnings.

Some employers have given practical recognition to the evil consequences of undue competition among the workers and of unwise efforts to increase production, arising under the system of payment by results. In certain cases they have found that the quality of the work suffers, that the amount of spoiled work increases, and that the physical health of the workers deteriorates. Accordingly, in place of the "straight" piece-rate system, they have introduced a "differential piece" rate system, in which the scale of payment is so regulated that the rate per piece diminishes when production passes beyond a desirable limit. Or they have introduced an additional bonus, based on the quality of the output and on the amount of spoilt work. In some instances a differential piece rate, of the kind just mentioned, has been introduced on the ground that the greatest effort is involved in the initial stages of output, and that subsequent output, being easier to produce, merits less reward.

In many industries, on the other hand, the effects of undue hurry or pressure to secure greater output have not been observed, or perhaps have been disregarded. Consequently some employers have introduced a differential piece rate based on a principle diametrically opposed to that just described. They maintain that increasing output deserves an ever-increasing rate of reward, inasmuch as the worker's efforts increase out of all proportion to the increasing amount of output. Indeed in some cases, two piece rates have been introduced, a lower and a higher rate, the latter only starting when a certain quantity of output has been produced, the former being so low that no indolent or inefficient worker could afford to remain on the job.

It is not only for the immediate benefit of his own pocket that the employer tends to cut the piece rate, but also because he finds that large earnings tend to bad time-keeping on the part of those who receive them, and to discontent among other workers who, owing to the nature of their employment, cannot be paid so liberally or according to the same system. In some cases

the employer has even abandoned payment by results, because his workers kept such irregular times after having earned sufficient for their weekly needs; this, however, argues an incapacity or unwillingness to consider less drastic remedies. The dissatisfaction felt by the less fortunately placed workers in a factory where some are engaged on a very profitable piece rate while others, such as labourers, clerks, and tool makers can only be paid by day rate, has been effectively met by the grant of an adequate bonus to the latter, all being then jointly concerned in the productivity and efficiency of the factory.

It is not surprising, then, that while the straight piece rate is usually preferred by the workers to any other form of payment by results, most employers favour either (i) the differential piece-rate system, or (ii) some form of bonus or premium system, in which extra earnings are added to the day rate and are dependent either upon the time saved in performing a standardised task, or upon the percentage of efficiency attained in relation to a standardised rate of output. The advantages of the differential

piece rate and of the various bonus and premium systems have been strongly urged by the pioneers of "scientific management" in the United States. There such systems have been sometimes admittedly devised not only to incite the worker to produce his maximum, but also to prevent him from earning what the employer considers would be an excessive wage, and to make it impossible for the less efficient worker to earn an adequate living. In America, however, there is (or has hitherto been) a plentiful supply of immigrant labour, and trade unionism is, by at least two generations, more backward than in Great Britain. In this country, the inhuman, mechanical features of "scientific management," which marked the inception of the movement, have led to its identification with industrial tyranny and servitude. Properly applied, however, the bonus and premium systems are conducive to smooth working, although they are not unnaturally apt to rouse in the worker a suspicion that his bonus or premium represents but a fraction of the legitimate profits of his work.

Systems of payment by results, other than

the straight piece-rate system, have been opposed by the worker also on the ground of their unintelligibility. The remedy for this complaint rests with the employer; a clear, comprehensible statement should accompany the payment of all earnings, setting forth how the amounts payable have been determined. The worker objects, too, that the rising differential piece-rate system and similar systems are unfair and disappointing to the operative whose daily output may happen just to fall short of the amount necessary for him to gain a higher rate, and that consequently they lead to dishonest juggling on his part with the output.

Both employer and operative must ultimately come to see that low output, so far as it results from inefficiency on the part of the worker, can be largely safeguarded by proper physiological and psychological tests applied at the outset of an individual's career (*cf.* Chapter III); that a range of individual differences in normal output must be established within which employment may be continued and below which change to a more suitable employment must be effected; that special arrangements must be made by the

community to provide a livelihood for those of its members who are mentally or physically incapable of attaining the normal limits of efficiency in any sphere of work; and that a satisfactory wage must be allowed for those who, through no fault of their own, are thrown out of employment.

But it is possible to take the view that innate differences in mental or physical ability should not determine the reward for work, so long as each worker makes the same effort in using his ability; or that every man deserves the same pay, whatever his natural capacity, just as every man exercises the same vote whether he be of unusually great ability or whether he only just escapes certification as being of unsound mind. Certain trade unions, as we have observed, are strongly opposed to any system other than a uniform day rate, even making it impossible for a worker to receive additional rewards for extra skill or application. Such an attitude is the inevitable consequence of the evil labour has suffered in the past at the hands of unscrupulous employers, especially of employers who are conducting small industrial concerns or who

have risen to their positions after passing through the ranks of labour themselves. For (with outstanding exceptions) those who are in command of small units or who have risen from the ranks make notoriously the worst officers. It is not surprising, then, that trade unions regard such systems, however excellent when properly applied under sympathetic management, as unfavourable to the principles of collective bargaining and to the good comradeship and organization of their members.

Under ideal conditions, the day rate has undoubtedly much to recommend it. Indeed in certain circumstances and occupations, where, *e.g.*, the highest quality of work is essential, where measurement of output is impossible (owing to its nature, its variable character, etc.), or where sufficiently thorough inspection of the work is impossible, it is the only satisfactory method of payment. Day rate has also the great advantage of allowing a greater variety of work to be performed during the day, thus lessening the ill effects of monotony. But it makes no differentiation between the good and the indifferent worker, and therefore tends to

a standard of mediocre uniformity in output and quality of production, unless other interests besides those of payment can be fostered. The participation of the workers in management may prove to be one of those interests; although it must be confessed that, save in times of national danger, the participation of our citizens in democratic government has not evoked a much deeper interest in the welfare of the country, nor has there been an adequate increase in the amount of unselfish work they are ready to perform on its behalf. To a small number participation in industrial management may afford a sufficient additional interest; with growing education and knowledge, its influence may be expected to increase. But for ages to come there must remain among us a considerable number of brute men for whom the reward of larger income and of shorter hours proves the main inducement for adequate effort, or whom nothing will stir so long as they are earning a bare sufficiency for their daily living. Under present conditions of humanity and society, day rate needs consequently to be combined, whenever possible, with some form of gradua-

tion of pay according to individual efficiency. Honesty, quality of output, amount of spoiled work, length and punctuality of service—all need to be taken into account, besides the mere quantity of work produced. There is already at least one trade union in which men are graded according to ability, where if a man considers he ought to be in a higher grade he applies to his employer; should the employer not agree, the man can appeal to his union for an examination; and if he fails to pass it, he pays the fee, whereas if he passes the examination, the employer pays the fee.

There can be no doubt, then, that under present conditions a flat day rate for all is psychologically unsound, unless there be grades of day rate, rewards for exceptional performances, and adequate opportunities for promotion to higher grades and for reversion to lower. A flat day rate can be combined, as we have already indicated, not only with a graded pay rate, but also with a piece-rate or bonus system; and the latter may be dependent not merely on individual effort but on the total output or profits, or on the total saving in cost to the

works. This should not only urge all to do their best, but it should prevent the jealousy, suspicion, and unhealthy rivalry among workers, engendered by the system of payment by individual results.

Indeed the advantages of pooling the results have been so far recognised that in certain cases workers and trade unions have insisted that piece rates and bonuses should be divided among the workers in a given shop according to its output. The results of such "collective," "group," or "gang" piece-rate or bonus systems are differently appraised, probably according to the workshop "atmosphere" of contentment or dissatisfaction prevailing. In some instances it is claimed that the more efficient workers in the group, feeling that they are producing for the benefit of their less expert or less industrious comrades who will equally share in the results, content themselves with doing only a moderate amount of work. In other instances, on the contrary, it is asserted that the abler workers exercise a most beneficial influence on the less efficient, by inciting them to greater activity, by instructing them in better methods of crafts-

manship, and by generally helping their weaker comrades where they need assistance. Indeed everywhere the workshop or office "atmosphere" seems of far greater importance than the system of payment in vogue, although doubtless the latter to some extent reacts on the former. It is probably not untrue to say that there is no well-recognised system that cannot be satisfactorily installed by a sympathetic management in which the workers have full confidence.

The method of a general pooling of individual results has been extended to the development of "profit-sharing" schemes. In many instances, however, such schemes are merely another name for "tips" bestowed on the workers according to the success of their efforts. The "shares" are usually distributed every six or twelve months, and the reward is consequently remote and relatively ineffective in the case of those who are only capable of taking a short view of the fruits of labour. It is also generally very small, averaging in this country only about six per cent. of the wages earned. For these and other reasons, profit-sharing does not satisfy the

individual worker; he suspects that an undue share of the profits still passes into the pockets of the capitalist; for he is not allowed, and is perhaps incompetent, fully to understand the basis on which the rewards received are allotted, he has no effective voice in the management of the works to which he belongs, and the rise or fall of his share may be due to conditions quite beyond his control, and may bear no relation to his own effort or responsibilities

Profit-sharing, therefore, can only be successful when it is carried out on lines which are explained to the workers and are understood and accepted by them; it must be a true and just sharing of profits, and must be associated with a share of labour in the management. So, too, when profit-sharing is extended to "co-partnership," the co-partnership must be one which is true and just, a co-partnership in intellect and feeling as well as in stocks and shares. If, as so often, it assumes the form of a condescending gift on the part of the directors, if (as in some cases) it involves a close prying into the home life of the workers in order to see if they deserve it, if the workers are debarred from exercising

any efficient voice in management, co-partnership becomes a system of doles and acquires all the evils of a charity scheme. Such schemes do not satisfy the trade unions because they fear that they will lose their powers of collective bargaining and, in particular, that the share-holding workers will refuse to strike in aid of their less fortunate comrades in other factories. Indeed this has sometimes been avowedly the object of employers in establishing schemes of co-partnership.

It is therefore not surprising that hitherto most profit-sharing and co-partnership schemes have met with little permanent success. But that is no reason why, if conducted on improved lines, they may not be successful in the future. Their psychological value is too obvious to need indication. There are some who think that ultimately we shall have profit-sharing not among individuals, not among groups of individuals, not even among firms, but in the form of industrial profit-sharing, the profits passing to the industry as a whole and their allocation being determined by a joint council representative of all concerned in their formation and

acting in the capacity of co-partners in the industry. But whatever our ultimate destination, progress must necessarily be slow until unselfishness and social service play a far more prominent part than at present, overriding the narrowness of personal egotism and the primitive, non-moral economic forces of supply and demand. Of one thing there can be little doubt, that the unlimited profits hitherto absorbed by capital will be regulated by law. When capital has been paid a due reward for its services, the remaining profits must be equably divided among all concerned in its production. Thus capitalism and employment will come to be rigorously distinguished—employment including both management and labour. To this end we are clearly approaching, the division being no longer between management and labour, but between capitalism and employment.

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CHAPTER VI

INDUSTRIAL UNREST

Industrial overstrain and the war—Overstrain and loss of higher nervous control—Loss of higher mental control—"Defence mechanisms"—The extremist employer and employee—Labour's attitude to Scientific Management—The worker's envy—The appointment of a works psychologist—Educational experiments—Labour and management—Security against unemployment, and share in management—The introduction of vocational guidance and selection—The introduction of motion study—Motion study, craftsmanship, and trade secrets—Vocational training and its organisation—Functions of a National Institute of Applied Psychology and Physiology.

CHAPTER VI

INDUSTRIAL UNREST

THE present condition of industrial unrest has been widely attributed to the recent war. When the life of a nation is at stake, overstrain is to some extent inevitable; and when "peace" has been signed, the effects of such overstrain cannot fail to manifest themselves. The writer is himself acquainted with the managing director of a factory who, with his works manager, burst into tears when the latter came to him with the news of the armistice. The editor of an important London newspaper complained that his assistants were breaking down one after the other when the strain of warfare was at an end, and were so sensitive that even the mildest rebuke provoked an outburst of emotion. We have ample evidence, from official inquiries, that during the war, the factory workers complained of feeling "stale," "nervy," "done up,"

"fairly whacked," especially during the earlier years when excessively long hours, with Sunday labour and a large amount of overtime, were so widely adopted. It is now realised that those conditions of work were economically unsound, and that a far greater output would have been—as indeed in the later years of the war it was—secured by the proper regulation of working hours, the dangers of overstrain being correspondingly lessened.

To some extent, as has been just stated, overstrain was inevitable during the war. For all classes were harassed by the demands of military service, by the uncertainties and sorrows inseparable from the battle field, by the restriction of food and lighting, by the fear of attacks from hostile aeroplanes, etc.

Such overstrain must produce a loss of "higher" control (*cf.* p. 41), leading to the short-circuiting of "lower" nervous processes, whereby their energy is wastefully dissipated. Thus arise that irritability, restlessness, and insomnia, so characteristic of "neurasthenia." There is a shortage of reserve force: the brain feels tired; headache and weakness of vision are

complained of; there is a general loss of muscular tone throughout the body—in the muscles of the blood-vessels, the heart, and other visceral organs, as well as in those of the limbs. The functions of the viscera are impeded owing to disturbance in the normal impulses passing along the vagus and sympathetic nerves. Those nerves control the organs of "internal secretion," *e. g.*, the adrenal bodies, the thyroid gland, etc. Disturbance of the functions of these glands, as is well known, causes disorder of the emotions; they (and other mental disorders) are also caused by disturbance of the vascular and digestive system. Thus disorders on the bodily side of the organism become reflected in disorders on the mental side.

Far more important, however, is the converse relation which the mental disorders more directly induced by overstrain exert on bodily processes. The failure of the higher intellectual processes results, on the psychical side, in a loss of control over the unpleasant conflicting experiences of the past, the memories of which, through such higher control, have hitherto—it may be unconsciously—been inhibited or re-

pressed from consciousness. Fatigue impairs this inhibition, and bygone conflicts, together with repressed unsatisfied impulses and cravings, are now free to surge forth from the unconscious to which they have been previously banished. Thus the mind becomes tormented with the emotional experiences of the past. These may be either domestic or industrial. On the industrial side, the desires and instincts connected with acquisitiveness, creative construction, self assertion, etc., which have been so strongly repressed among workers in modern industry and commerce, escape from bondage. Neither over the worries of the past, nor over those of the present, has the self any adequate mastery; and it has no longer the power to view them in proper perspective. They are like restive horses which have escaped from control and bolt away, bearing their driver along with them. The emotional experiences thus engendered are accompanied by over-stimulation of certain organs of internal secretion, exhaustion of which reacts in turn harmfully on the organism. A shortage of psychical, as well as of physical, reserve force arises.

Thus the overstrained person becomes unduly irritable, and sensitive, and lacking in self confidence. He attaches inordinate importance to trifling lapses of morality on his part or to small injuries received from others. He hugs his fancies or exaggerated sins, grievances, sorrows, or disappointments, and is unable to dismiss their worries from his mind.

Nature may come to his aid by subjecting his emotions to the process of "projection." Instead of continuing to reproach himself, he may (quite involuntarily) come to believe that it is others that are speaking ill of him; thus are formed delusions of persecution or suspicion. Another way in which the self may be secured from the effects of undue depreciation and the feeling of inferiority is by the process of "inversion"; undue shyness may become inverted into boisterousness, subservience into defiance, cowardice into foolhardiness, the desire for the opposite sex into hatred of it, and so on. Yet another escape from "facing the facts" is offered by "rationalisation," in which the true causes of one's emotional conduct are replaced by reasons which are invented subconsciously

but are accepted with full belief that they are genuine explanations and excuses for one's feelings and behaviour.

Such "defence mechanisms," as they have been called, may come into play in any insoluble emotional situation. In some degree they are responsible for the present pathological condition of industrial unrest. Each knowing that he has much to reproach himself for, both employer and employee unconsciously seek to escape from consequent self depreciation by fixing the blame on the other. In all branches of industry and commerce, both on the side of management and of labour, uncertainty and distrust, irritability and defiance prevail. Output becomes restricted, and a vicious circle is completed by the atmosphere of unrest in turn produced by conscious restriction of output.

Thus unrest arises not so much from merely physical overstrain as from the effects of worries and mental conflicts of all kinds, *e.g.*, the unsatisfactory conditions of modern industrial employment and its failure to satisfy the natural instincts and emotions (*cf.* pp. 75, 140), which have consequently to be suppressed. Home

troubles, dating often from early childhood, become another frequent source of worry. Such worries produce their effect especially when sown on a favourable soil. This soil has been called the "psychopathic disposition"—an innate tendency to mental instability, sensitivity, and discontentment, and to erratic mental development.

However provoked, such mental instability provokes industrial unrest, not only general but also individual. The mentally unstable employee is an irritant to his fellows, and a nuisance to the management. His kind is responsible for much of the existing unemployment and labour turnover. Ever restless himself, he is continually being discharged from one job to another as a worthless worker. He becomes more and more unfitted for a normal environment, and finally joins the ranks of the unemployable, the alcoholic, the criminal, or the insane.

We now know that, by the timely application of psychotherapeutic measures (based on the recent developments of abnormal psychology), and by a judicious selection of environment,

such workers can, like early tuberculous patients, be prevented from going downhill; many of the emotionally unstable can be healed; and many of those with insane "egocentric" tendencies or with defective intelligence can be prevented from becoming a danger to themselves or to society.

It would be absurd, then, to attribute the present industrial unrest merely to the strain of warfare. Such unrest existed, though by many unrecognized, long before the war. It was becoming more intense during the period immediately preceding the war. Employers and employees had by then become definitely solidified into separate groups, each imbued with what has been termed its own "herd spirit," each developing purposely or instinctively its own defences, each resolved to defend his own position and to demolish that of the other "herd."

The weapons of defence and attack used in such industrial warfare may be well seen in a comparison of the standpoints of the extremists on the two sides to-day. The extremist employer, refusing to "face the facts" of modern

industrial conditions, insists on keeping labour "in its proper place." He claims the right to deal as he pleases with the men whom he employs. He resents interference from outside sources. He denies any responsibility for the welfare of his workers; their duty being to work, his to pay them wages. If he has been "through the mill" himself, he argues that "what was good enough for me when I was a lad is good enough for you now." He objects to any improvements in education or other social conditions, on the ground that they make the worker more discontented with his lot. He regards labour as inevitable drudgery, and as a commodity purchasable according to the strict laws of supply and demand. His aim is frankly to "score off" it whenever possible, and to break up the trade unions which oppose his unfettered progress at every step. "Let others rise as he has risen" is his motto—and "the devil take the hindmost." He looks on the trade unions as hostile associations bent on getting for their members as high wages for as little work as possible and on robbing him of what he considers the just fruits of his enterprise. He

argues that if the workers pursue their present policy of restriction in output, he has the same right to restrict their pay and their control over industry. He may long ago have achieved the ideal from which he set out—of making a fortune; his continuance as an employer now being due to an unquenchable thirst for industrial adventure, greater power, and fresh conquests.

The extremist employee, armed with "defence mechanisms" against his feelings of inferiority or self-reproach (*cf.* p. 142), smarting under injustice, imagined or actual, presents a similarly "impossible" attitude. Why, he asks, should I increase my power of production, if so large a share in the resulting profits goes to the capitalist? Why is it necessary for the capitalist to reap enormous interest on his capital without serious risk, if he is willing to lend money to the State at the rate of five per cent.? Why should I be in favour of motion study, if it is going to force me into a monotonous routine method of work and to transfer all craft knowledge and skill from my possession to the department of management? What is the use of talking to me of vocational selection, until my

"unfit" comrades are secured from unemployment, and until true vocations have been established throughout the world of labour? Does the textile industry, for example, offer a properly organised vocational system, when fifty per cent. of the boys who enter it are said to leave it before they reach the age of twenty-two? Do you call the work of a postman or a porter a vocation? What chances are offered in such occupations for escape from a soulless life of unrelieved monotony? Are high productivity, good wages, and short hours the ultimate objects of human existence, or should not the worker rather aim at a fuller, more interesting, and intellectual life, and at the exercise of the higher duties of citizenship? Is it inevitable that rulers and ruled should continue to exist as two distinct and opposing classes, and that the former should be in a position to skim off from the latter all the cream of leadership and ability in the schools, factories, or businesses, for admission into their own class and for desertion from the ranks into which they were born? As a worker, I demand an adequate share in the control of the work in which I am engaged,

just as I have a vote in the government of my country. I refuse to remain a mere "hand"; I want to use my brain. Only then am I prepared to consider the application of scientific organization and management. Before this can be done, the whole social fabric needs reconstruction.

There is undoubted truth in the positions of both extremists. In all ranks of society there are men who merely desire to go through life reaping the maximum reward for the least possible effort—men of brute intelligence, working selfishly for their own ends, caring nothing, and indeed incapable of appreciating the needs and the position of others. Alike among employers and among trade unions there are some who have shown an unreasonable spirit of narrow-mindedness and selfishness. But in many instances this has arisen largely from avoidable mismanagement and misunderstanding in the past, from efforts to protect their weaker comrades or to preserve the existence of their own "herd." The question is, how far will it disappear with the spread of higher morality, increased responsibility, im-

proved education and the advancement of science?

There can be no doubt that Labour is rightly opposed in this country to the introduction of the early American methods of scientific management. It was at first conducted there with far too little regard of the worker's standpoint. The organisation of Labour in America is still far behind that in this country. Moreover, methods which may have obtained success in one part of the world cannot be imported wholesale into another where conditions are different. The impartial observer cannot regard with satisfaction the huge profits reported from the early use of scientific management in America and, at the same time, the relatively insignificant advance in wages paid therefrom to the workers. The impartial observer cannot countenance motion study if its ideal is to encourage types of workers who "more nearly resemble in their mental make-up the ox than any other type," or if the worker is to be told "You know just as well as I do that a high-priced man has to do exactly as he's told from morning till night." Nor can he deny the justice of the

worker's demand for greater industrial control in these days of government by consent, of increasing democratic spirit in education, and of growth of personality and responsibility. Especially after the experience of the war, for good or evil, class distinctions are everywhere breaking down, and the former hard-and-fast line of cleavage and opposition between management and labour must disappear in the course of social evolution. Leadership and management must continue to exist, but "respect" must be transferred from mere social position to personal ability and efficiency.

It is of little use for the employer to point out to the worker that more than two-thirds of the profits of capital goes into the pockets of the employed, or that if the whole of those profits were divided among the inhabitants of the United Kingdom, each individual would get only about a shilling a day. Whether such statements be true or not—whether account is, or should not be, taken of the profits arising from royalties, and the private ownership of land and raw material—the worker still resents the huge earnings of individual absentee direc-

tors and shareholders. He is filled with envy at the sight of his employer's luxurious motor car, the rich furs and rare jewels of his employer's wife, the splendid educational opportunities of his employer's children, when he contrasts these with his own conditions at home; when he compares his own intelligence, or his own insecurity of employment, with that of his employer; when he realizes how inefficiently management is organised by the firm employing him. It is but the natural result of spreading education and increasing responsibility that he begins to resent dependence on his employer; especially if he be so situated that he sleeps on his employers' property, that his children are educated in his employers' schools, and that the very streets in which he walks are owned by his employers.

Experience has shown that vocational selection and motion study cannot be begun without the full knowledge and consent and co-operation of all concerned. They must be introduced gradually but not by stealth, little by little but not unconsciously; otherwise suspicion and misunderstanding are bound to arise. The fol-

lowing instance will serve to illustrate the difficulties which are to be encountered and the manner in which they may be met, in a firm the directors of which were desirous of appointing an expert worker in industrial psychology to their factory. The workers' representatives were asked to consider the appointment; and after its objects had been explained to them in a lecture delivered by a trained psychologist, they met and framed the following questions which they put to their directorate.—Will the directors consent to the formation of a committee of six persons, half of them to be appointed by the workers, half by the management, to control and to direct the activities of the expert? Will the committee be empowered, in case of matters seriously affecting any section or department of the works, to meet the sectional or departmental council, and to discuss the proposed action? Will the expert not begin any inquiries or put into force any fresh methods, until they have been submitted to the committee? The directors agreed that the committee should decide the sphere of work within which the expert investigator should work;

they also agreed that if any step proposed by the expert were considered detrimental to the interests of the workers, the committee should be empowered to discuss the question with the sectional or departmental council before action was taken. The workers' representatives further asked—Will the piece rates be cut if there is increased output? How will the men on day rates be affected? If changes in working methods occur, what will happen to any man who may be thereby displaced? To these questions the directors replied that if a process was revolutionised as a result of study, a new piece rate would have to be agreed on, the workers receiving at least as much for the same amount of effort as before, and the absolute weekly wage never being reduced. The directors also pointed out that if the whole saving due to motion study were given to the workers immediately concerned, the workers in those departments which at the present time are so efficient that little or no improvement can be made, would be penalised and dissatisfied unless the saving was more widely distributed (*cf.* p. 128). If motion study were undertaken, there could never be more

than a few men displaced at any time, as it could be applied only to one or two processes simultaneously; there should consequently be no difficulty in absorbing such men in a business which is rapidly growing in efficiency.

In general the trade unions have raised no opposition to motion study so long as the workers have been satisfied in the particular factory in which it has been introduced. But the satisfaction of the workers can only be secured by perfect understanding and by full confidence between them and their employers; and this again can best be obtained by the co-operation of both in industrial control.

In this connection it is surely noteworthy that several educational enthusiasts claim unqualified success from the introduction into schools of class-room committees and courts of justice, appointed from among the school children by themselves and responsible for all disciplinary punishments and regulations. Is not this a possible indication of what may be successfully effected in the factory or office? An "advanced" teacher divided his class into two, pitting one side against the other in school

work as in sport, and allowing the members of one side to examine and to "score off" those of the other. Without supposing that scholastic and industrial conditions are identical, or that these "advances" are free from danger, especially under inefficient mastership, may we not infer that industry and commerce have something to learn from educational experiments of this kind? May we not hope for similar experiments in regard, say, to the abolition of irritating restrictions and ineffective punishments, and for a method of widely publishing their results? If, for example, the worker be allowed to smoke during his hours of employment, will he indulge to such a degree that his work suffers or that his non-smoking fellow-workers complain? The little information we possess rather indicates that, perhaps after a brief period of initial excess, he will smoke less than may be expected, owing to the very knowledge that he may smoke if he so wishes, and that he will work better and in greater peace of mind, no longer running off at odd moments of the day to obscure places where he may light a "fag" in secret. Or again, is it certain that the present system of

fines and exclusions has any real effect in reducing bad time-keeping, or that the practice of "clocking off" at the end of the day's work is really beneficial to industry and commerce?

How and to what extent labour will take part in management, is by no means easy of solution. There are extremist employers who would "die in the last ditch" rather than admit their workers to the least share in management. There are extremist employees who consider that co-operation between employer and worker is impossible under present social conditions, that it would not result in any permanent benefit to the worker, that the workers must appoint the government of their industry just as they determine the government of their country. But if, with the prospect of steering a middle course between obstinate conservatism and wild revolutionism, we look at the present system of parliamentary election, we may perhaps better realise whither steady progress will bring us. In the early days of the House of Commons, its activities and responsibilities were far more restricted than now. So any Board of industrial management on which the workers are first

represented may be expected to grow more and more "democratic" with increasing age and experience. Despite popular suffrage, the real control of the country has suffered only gradual change. Electioneering bribery is far from being extinct, although its cruder methods have long ago disappeared. Many of the same men —representatives of the same families—are elected time after time; ministers are appointed who know practically nothing of their "jobs" and are dependent principally on the expert advice they receive from their permanent staff. The changes towards a true democracy that have occurred are of a slow evolutionary character. In a popularly controlled industry, a similar history may be anticipated. Clearly it is a prime necessity that a body of workers, selected by and from among themselves, should be forthwith chosen, who may be trained for the higher duties of the directorate. Otherwise (unless, like many a present director, he is to sit as a "sleeping partner") any representative of the workers, upon being elected to the board, must spend his first eighteen months or two years in learning the complex details of his new

environment; throughout this period he must repress his instincts to self assertion and keep silence owing to his ignorance; and then at the lapse of those two years it may well happen that the workers will elect another inexperienced representative in his place. Whereas if the representatives were chosen from a popularly elected, properly qualified body of workers, the difficulties arising from ignorance and inexperience would be enormously reduced.

At the present time a large factory or business may be likened to the Army or any other Government Service. The managing director can know as little of his thousands of employees individually as a commander-in-chief knows of his soldiers. The foremen are too often chosen because of their driving power—their power to enforce discipline, and their ability to get the most work out of their workmen. They are therefore apt to lack the necessary sympathy and breadth of view. They become the N.C.O.'s of the factory. As soon as they are promoted "from the ranks," they tend to lose what spirit of comradeship they once shared with their fellow-workers, and to be regarded by them with

the same suspicion and distrust as they feel so commonly towards their employers. Like the N.C.O.'s, the foremen's job is to "get a move on." They are responsible to their superiors for this and for the preservation of discipline. It may lie in their power to give a favourite a soft job and summarily to dismiss any worker who has "got up against" them. If the worker has the right of appeal against dismissal, the managing director can seldom (save in cases of most palpable injustice) reverse the decision of his foreman without risking loss of discipline among his men and reducing the foreman's prestige in the future. The foreman is not going to be bothered with suggestions from the man under him. As in the Government Services, so in industrial concerns, the easiest line to take in regard to a recommendation is to "turn it down." If he passes it on to his immediate superior, he will himself be considered a nuisance. Thus all interest and keenness tend to be smothered under the deadening weight of mechanical uniformity. The spirit of interest and initiative in the employee, as in the private, is too often "broken." It is not sur-

prising that one so seldom meets with the complaint of monotony.

There are other conceivable analogies which may also hold between large firms and a Government Department, *e.g.*, the uniformity of pay among different workers of the same rank despite their different abilities; the difficulty of removing incompetent but influential superiors, the reluctance of lower officials to accept responsibility for new actions demanded by new situations; the ignorance of the lower-grade workers of the meaning of orders transmitted to them; the implicit unquestioning obedience expected from them; the frequency of inter-departmental jealousies and squabbles, etc. Let us ignore the attitude of the "extremist" employees who stake all hopes of progress in violent social revolution. Let us remember that the extremists form but a small fraction of employers and employees—though, it must be confessed, their influence is out of all proportion to their numbers. Let us rather turn to what is likely to satisfy the majority of those engaged in industry and commerce, who retain their faith in orderly progress and in the possibility

of reconciliation, and let us examine how some of the difficulties that confront us may be met.

There are two fundamental conditions demanded by the workers which must be satisfied at the outset, viz., security against unmerited unemployment and a share in management; and unless these are established, further appreciable progress is impossible. Assuming that this has been done, let us proceed to consider some of the remaining changes needed and the difficulties to be encountered.

Vocational selection is bound to come. Properly conducted, it must prove an immense help both to management and to labour, for it avoids the waste and torture that result from placing the "round peg in the square hole." But it needs applying with judgment and sympathy. It would be useless to *compel* an individual to adopt any calling which the selection expert considers suitable, and it would be vain to prevent him from taking up the work which he insists on attempting. Vocational psychology can only be advisory, not compulsory, save when it is applied to select the best applicants for a vacant job.

So, too, in regard to motion study. Once an improved method of working has been established, it would be folly to demand that all operatives must adopt that method, if they can show that by another method they can produce the same quality and quantity of output without more fatigue. To maintain that there is but *one* best method, suitable for all purposes and adapted to all types of worker, is a psychological fallacy of the first exponents of so-called scientific management (*cf.* 21, 24), and only justifies the workers' fears that motion study will convert them all into blind, soulless machines. Just as there are different first-rate styles of piano- or tennis-playing, just as it is difficult to know which of these first-rate styles is the best, so undoubtedly in methods of work, there are several best styles which are best suited to different individuals; and it rests with industrial psychology to investigate the nature of these differences. Habitual action is to a varying extent inevitable in all manual work. The object of motion study is to arrive at the best methods of work, and to see that the newcomer acquires the habit of using a good method in-

stead of one which he has picked up by accident or tradition. For "muddling through" and hide-bound custom are the worst enemies of progress.

The workers fear that motion study will rob them of all craftsmanship and will result in all craft knowledge passing into the hands of management. They fear that they will be deprived of "craft skill" and reduced at most to the possession of "job skill." Such fears are reasonable if the study is applied solely in the interests of management. The deplorable history of the welfare movement shows what may happen when a scheme which will largely benefit the workers is imposed on them without their co-operation or by persons improperly trained for the work. Ample causes must arise for complaint, and a (generally baseless) suspicion is engendered that the employer is introducing the "welfare" movement in his own interests, so as to throw dust in the eyes of his workers which shall blind them to a view of their helplessness and dependence, or so as to administer a narcotic which shall lull them with a sense of false security.

It is, therefore, essential that the application of motion study shall be controlled by the workers. With the improvement of their economic position in industry, craftsmen will no longer find it essential or even desirable to keep their methods of work secret. There was a time when the methods of medicine and surgery were secret and were transmitted orally from master to apprentice. But in these days, only bone-setters and the vendors of quack medicines conceal their craft knowledge; new discoveries are published in the medical press as they are made, and they are communicated to students in the course of training. Is it not obvious that the secrets of industrial and commercial craftsmanship must sooner or later become similar public property? Not only the workers but also the employers require education in this direction. A visitor may enter a factory where, as a special privilege, certain trade secrets are shown him by the employer. He may then proceed to a neighbouring factory, only to find the same secrets common knowledge and in full practice. In this respect America is far ahead of this country. Not long ago, a University

lecturer on industrial organisation approached several British firms for details of their methods of planning, routing, costing, etc.; and he received the invariable reply that such methods were secret and could not be communicated. He wrote thereupon to various firms in America and at once obtained the information he desired for his lectures.

The fears of the ill-effects of motion study can only be met by improving the education and the outlook both of employers and of workers; by exhorting employers to take their workers more into their confidence; by providing the workers with wider economic, literary, athletic, æsthetic, and scientific "continuation" instruction; and by instituting adequate incentives (moral and intellectual, as well as financial) which will enable them to show keener interest, instead of apathy and lethargy, in their work and to take greater pride in the well-being of the factory or business to which they belong. They must be provided with a truly vocational training which will fit them for promotion to various higher posts and enable them to change from one type of work to another, so that they may

be released from the soul-starving tedium of monotonous routine, induced to devise and to communicate further improvements, and better enabled to give play to self expression and creation in their work. There was a time when a locomotive builder knew all about the locomotive as a whole; now all his life may be spent in making one small engine part, and he may be ignorant of any other process or of the relation of his work to the whole. Clearly the evils of such specialisation must be combated. Every occupation must be so far as possible raised to the dignity of a true vocation by systematic instruction.

To secure such changes the co-operation of trade unions is essential. If a bricklayer is to be trained in some other occupation which will enable him to work during times when he would otherwise—through adverse weather or through industrial fluctuations—be thrown out of employment; if the compositor is to be permitted to relieve the monotony of his work by an exchange of job with his comrade engaged in a different kind of printing, small trade unions must combine with larger unions, and they will

require guarantees that no suffering will occur through unemployment resulting from such change or interchange of work. There are hopeful indications already of the combination of trade unions, and of their recognition that higher functions devolve on them besides looking after the mere material interests of their members.

Hitherto training has not been adequately organised, either on the side of capital or labour. Neither management nor labour has hitherto received any systematic instruction in the duties it has to perform. Each picks up his knowledge anyhow. The foreman, on being appointed, settles down to his new work as best he can. The apprentice may have the good fortune to be taught by a competent worker who can and will teach, or he may fall into the hands of a competent worker who is incapable of teaching or of one who is wholly inefficient. His opportunities for learning are largely a matter of accident. He may suffer through circumstances which are obviously remediable, and for which he is wholly irresponsible.

These various remedies for individual unrest

depend, for their efficient application, on the assistance of an independent National Institute of Psychology and Physiology applied to commerce and industry, established under conditions receiving the approval and justifying the confidence both of employers and employed. Conducted without profit by impartial scientific experts, such a National Institute, which in fact has just started on its labours, will confer incalculable benefits by resolving the many difficulties pertaining to Mind in Work.

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